UNITED STATES

AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 2001/2002 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
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TABLE OF CONTENTS

BACKGROUND

The long-term objective of the U.S. AMLR field research program is to describe the functional relationships between Antarctic krill (*Euphausia superba*), their predators, and key environmental variables. The field program is based on two working hypotheses: (1) krill predators respond to changes in the availability of their food source; and (2) the distribution of krill is affected by both physical and biological aspects of their habitat. To refine these hypotheses a study area was designated in the vicinity of Elephant, Clarence, and King George Islands, and a field camp was established at Seal Island, a small island off the northwest coast of Elephant Island. From 1989-1996, shipboard studies were conducted in the study area to describe variations within and between seasons in the distributions of nekton, zooplankton, phytoplankton, and water zones. Complementary reproductive and foraging studies on breeding pinnipeds and seabirds were also accomplished at Seal Island.

Beginning in the 1996/97 season, the AMLR study area was expanded to include a large area around the South Shetland Islands, and a new field camp was established at Cape Shirreff, Livingston Island (Figure 1). Research at Seal Island was discontinued due to landslide hazards. Shipboard surveys of the pelagic ecosystem in the expanded study area are accomplished each season, as are land-based studies on the reproductive success and feeding ecology of pinnipeds and seabirds at Cape Shirreff.

The region-wide survey designs (Legs I and II, Surveys A and D respectively) in the vicinity of Elephant, Clarence, King George and Livingston Islands are described in Figure 2. Stations located to the west of Livingston and King George Islands are designated the "West Area", those to the south of King George Island are designated the "South Area", those around Elephant Island are designated the "Elephant Island Area", and those south of Elephant Island are designated the "Joinsville Island Area". The survey grid was expanded this year to include stations in the Joinsville Island Area in order to understand the dynamics and influences of the Weddell Sea on the AMLR survey area.

This is the 14th issue in the series of AMLR field season reports.

SUMMARY OF 2002 RESULTS

The Russian R/V *Yuzhmorgeologiya* was chartered to support the U.S. AMLR Program during the 2001/02 field season. Shipboard operations included: 1) two region-wide surveys of krill and oceanographic conditions in the vicinity of the South Shetland Islands; 2) calibration of acoustic instrumentation at the beginning and end of survey operations; 3) a fur seal pup census at selected sites throughout the South Shetland Islands (Leg I); 4) a joint Zodiac/ship inshore survey of krill and oceanographic conditions near Cape Shirreff (Leg II); 5) deploying a buoy instrumented with acoustical sensors and buoy-to-shore telemetry in the vicinity of Cape Shirreff (Leg II); 6) collecting multi-scattering total target strength measurements of live animals (Leg II); and 7) shore camp support. Land-based operations at Cape Shirreff included: 1) observations of chinstrap, gentoo and Adélie penguin breeding colony sizes, foraging locations and depths, diet composition, breeding chronology and success, and fledging weights; 2) instrumentation of adult penguins to determine winter-time migration routes and foraging areas; 3) observations of fur seal pup production and growth rates, adult female attendance behavior, diet composition, foraging locations and depths, and metabolic rates; 4) collection of female fur seal milk samples for determination of fatty acid signatures; 5) collection of fur seal teeth for age determination and other demographic studies; 6) tagging of penguin chicks and fur seal pups for future demographic studies; and 7) establishment of a weather station for continuous recording of meteorological data.

An oceanic frontal zone was mapped along the north side of the South Shetland Islands, running parallel to the continental shelf break and separating Drakes Passage water to the north from Bransfield Strait water to the south. As Leg I progressed, the frontal zone was further offshore with a plume of transition water situated from the southwest to the northeast with an eddy extending from the middle to the northwest quadrant of the survey area. Overall, as in previous years, the southern part of the survey area is mainly Bransfield Strait water (Water Zone IV) with in intrusion of Weddell water (Water Zone V) from the southeast. The northeast axis through the center of the survey area is dominated by transition water (Water Zones II and III) meandering into the north. The northwestern area in influenced by Drake Passage water and the southern boundary of the Antarctic Circumpolar Current (ACC). Chlorophyll concentrations were the opposite this year as compared to last year; concentrations were higher in coastal stations last year and this year concentrations were higher in the pelagic stations of the survey area. Highest concentrations of chl-*a* this year were observed in the West Area off the shelf in the deeper water stations. The lowest chlorophyll concentrations were seen near the Weddell Sea. Highest densities of krill were mapped over and offshore of the northeast Elephant Island shelf. Mean and median krill abundance in the Elephant Island Area was slightly higher in January 2002 than in 2001. Larger sized krill (>32mm) were rare in the South and Joinville Island areas whereas juvenile krill constituted 88-93% of the catches in the southern part of the archipelago. Krill larvae were present in greatest concentration in the Elephant Island Area. Overall krill abundance was higher during Leg II compared to Leg I this year due to the patchier distributions of krill collected during Leg I. This year's survey indicates a prolonged, and fairly successful krill spawning season. The overall abundance and size maturity composition indicated; extremely good proportional recruitment of the 2000/01 year class, essential absence of recruits from the 1999/00 year class; and markedly reduced numbers of krill from the highly successful 1995/96 year class. Mean salp abundance was substantially larger during Leg II when compared to Leg I. The late season spurt of aggregate salp production in 2002 is similar of the 1997 season, which preceded a major salp year in 1998. Copepods dominated the zooplankton assemblage. This, and other aspects of the zooplankton assemblage, suggested that 2000 and 2001 may be classified as transition years between a salp-dominated community and a copepod-dominated community. Additionally with the expanded survey grid this year came the introduction of higher latitude zooplankton taxa, which previously had not been encountered. This was especially true for the Joinsville Island Area, influenced by the Weddell Sea and the South Area adjacent to, and influenced by, outflow from the Gerlache Strait.

The inshore survey near Cape Shirreff (Figure 3) was accomplished using a 5-m Zodiac configured with a 120kHz echo sounder, an underwater video camera, a CTD, several continuously recording sea surface and meteorological sensors, two GPS receivers, a radar, and emergency equipment. The Zodiac was used to map krill within 15 nautical miles of the Cape while the ship surveyed further offshore. The survey was staged from the field camp and conducted over a 7-day period. Substantial amounts of krill were mapped inshore of the region surveyed by the ship and the feasibility of using a small boat to conduct inshore surveys in Antarctica was demonstrated.

The 2001/02 population counts at Cape Shirreff represents the lowest chinstrap penguin count on record. The gentoo penguin population was down considerably from last year, but was within the five-year averages. Mean chinstrap penguin clutch initiation dates coincided exactly with dates from the past two seasons; however, gentoo penguins laid eggs a mean ten days early than previous seasons. Chinstrap penguin reproductive success in 2001/02 was the lowest on record for Cape Shirreff, while gentoo penguin reproductive success was within the five-year averages. This season represented a 23.7% decline for chinstrap penguins and an 18.3% decline for gentoo penguin chicks, compared to the 2000/01 counts. This season we had a significant increase in the number of known-age chinstrap and gentoo penguins breeding. These birds were banded as chicks at Cape Shirreff and have returned to their natal colonies to breed. The dominant prey species in the diet samples was krill, which were found in 100% of samples from both chinstrap and gentoo penguins. Analysis of length-frequency distribution of krill in the penguins' diets revealed a wide range of krill size classes from 18mm to 63mm. Chinstrap penguin diets were composed almost entirely of krill with only 15% of samples containing otoliths or trace amounts of fish. Gentoo penguins consumed more fish with 70% of the diet samples containing some portion of fish in addition to krill. Results of satellite tagged birds revealed that the birds were foraging farther offshore than in the previous season, a pattern likely to account for the longer trip lengths we found in 2001/02. This season birds traveled up to 30km offshore to feed at the shelf break in January 2002. This represents a very different foraging pattern from data gathered during the 2000/01 January period, when all penguin foraging activity was confined to the shelf area within 10km of the colony.

The 2001/02 season was better for Antarctic fur seals by several measures than the 1997/98-1999/00 seasons. It was similar in some respects to last year but mean foraging trip duration for lactating females was slightly longer than in 2000/01. Fur seal pup production at U.S.-AMLR study beaches on Cape Shirreff increased by 8.3% over last year. The median date of pupping based on pup counts was one day earlier than the last two years and three days earlier than in 1997/98 and 1998/99. The mean trip duration for adult females' first 6 trips to sea was slightly greater than last year (3.18 vs. 2.71 days) but still less than from 1997/98 to 1999/00 (4.19, 4.65, and 3.47 days, respectively). Fur seals this year had slightly more fish in their diet than in previous years. The mean length of krill in fur seal diet decreased this year over last year, reflecting the same results as found in net tows from the oceanographic survey.

A fur seal survey was conducted at 13 sites throughout the South Shetland Islands (Figure 4). Discovered in 1819, the South Shetland Islands soon became the focus of intensive sealing efforts. Abundant, but never quantified, Antarctic fur seal populations were exterminated by 1874 and did not begin re-colonizing until approximately 80 years later. The first reported pups born post-exploitation were found at Cape Shirreff, Livingston Island in January 1960. In 1987, an archipelago-wide aerial and ground census identified breeding colonies and substantial increases in pup production. A ground survey of all known fur seal colonies from Smith to Elephant Islands was conducted from 30 January –5 February 2002. Multiple counts of pups at each colony were conducted to establish confidence limits on pup production. Total pup production was 10,057 (±142); 85% were from Cape Shirreff (64%) and San Telmo Islands (21%). Dead pups accounted for 1.37% of the total. A comparison with previous censuses over a 15-year period (1987, 1992, 1994, and 1996) indicates the rate of increase in fur seal populations has diminished substantially. The averaged annual rate of increase from 1987-1994 was between 13.5-13.9%. From 1994-1996 it was 8.5% and from 1996-2002 the average annual rate was +0.9%. Pup production at individual colonies varied with some increasing and others decreasing. The San Telmo Islands had the largest decline from 2,684 pups in 1996 to 2,124 in 2002 (-3.5%/yr). Pup production at Cape Shirreff increased from 4,968 to 6,453 pups (5.0%/yr) during the same period. Cape Lindsey, Elephant Island, and the Seal Islands had averaged annual declines of –9.4 and -6.3% from 1996-2002.

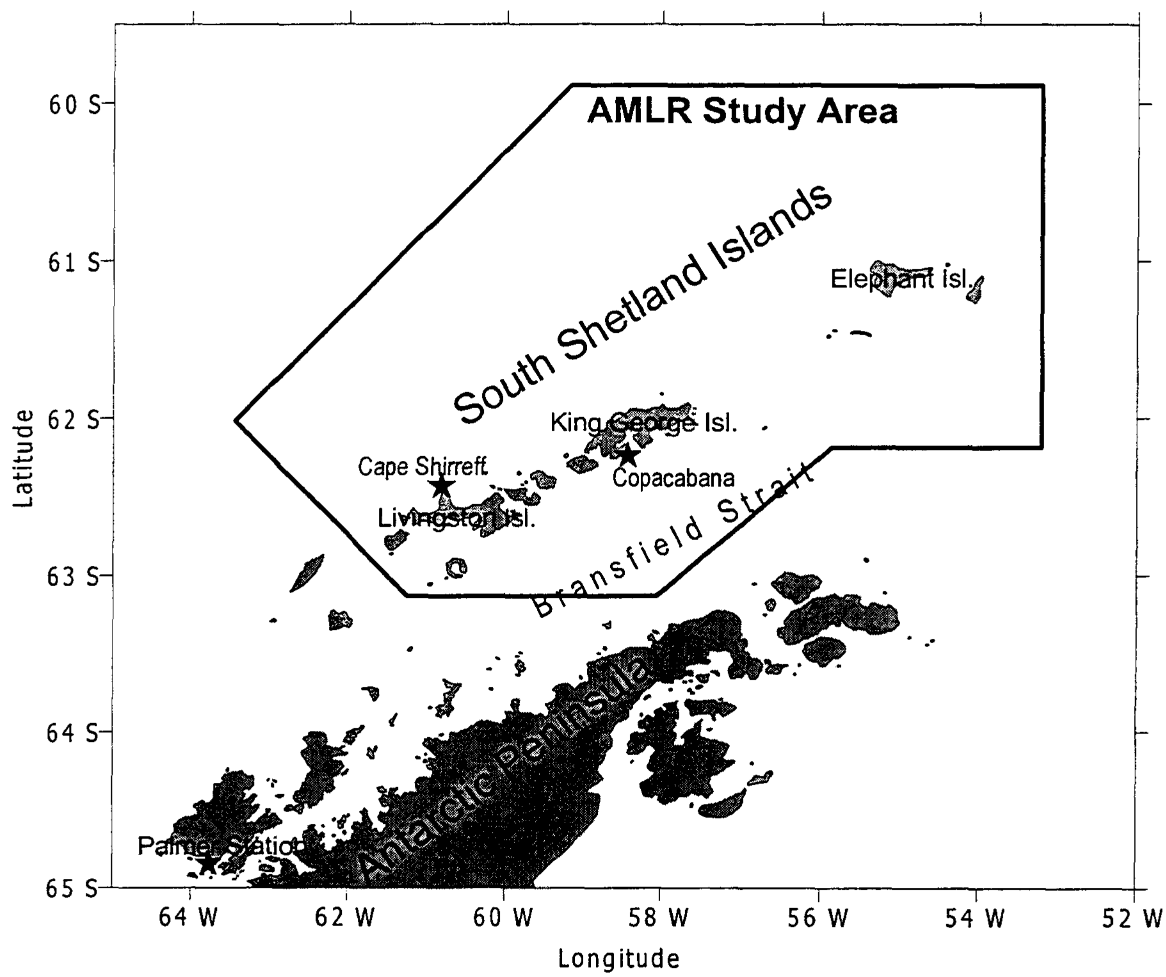


Figure 1. Locations of the U.S. AMLR field research program: AMLR study area, Cape Shirreff, Livingston Island and Copacabana, King George Island.

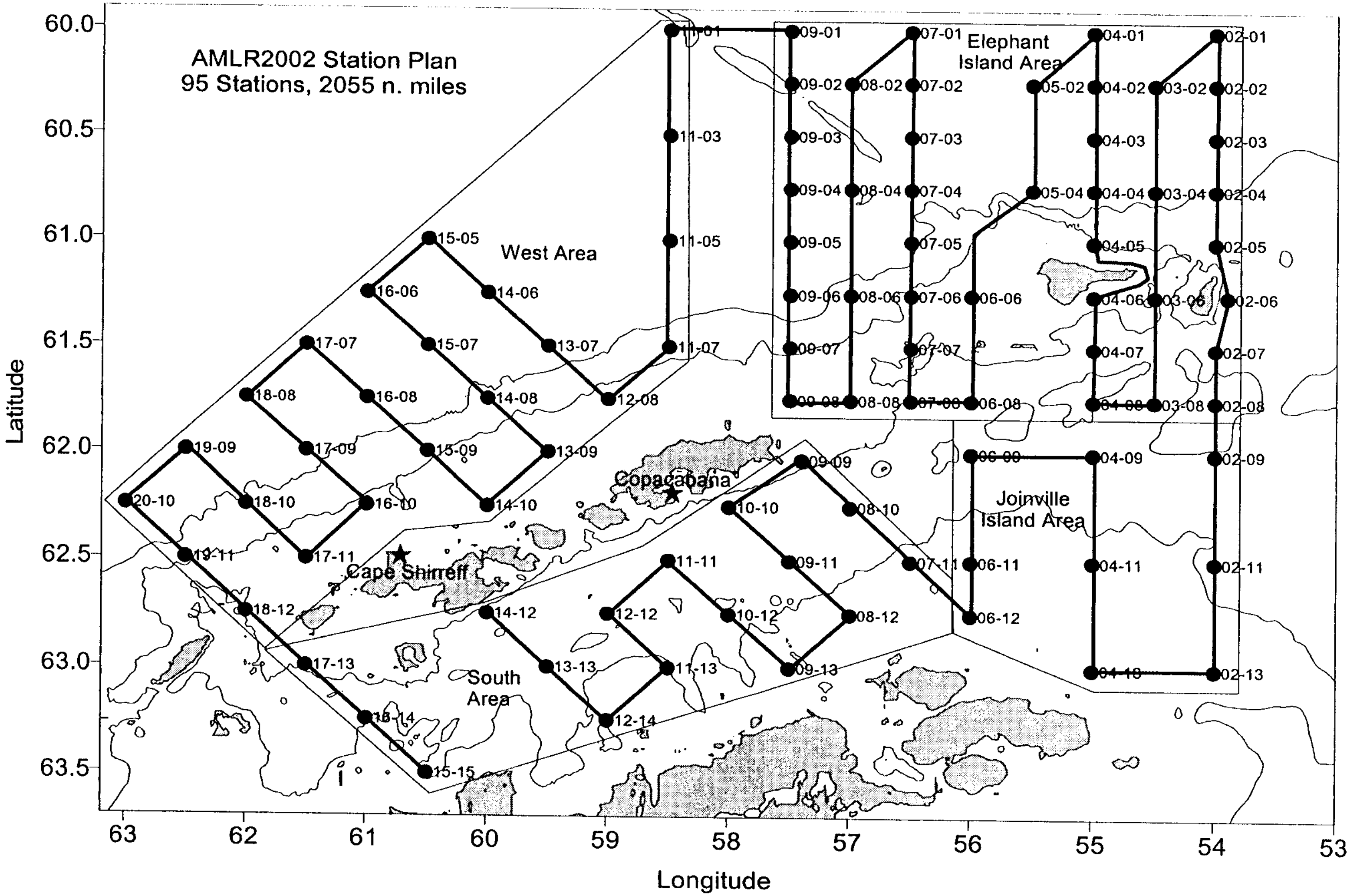


Figure 2. The large-area survey for AMLR 2002 (Survey A & D) in the vicinity of Elephant, Clarence, King George and Livingston Islands. Stations located to the west of Livingston and King George Islands are designated the "West Area", those to the south of King George Island are designated the "South Area", those around Elephant Island are designated the "Elephant Island Area", and those south of Elephant Island are designated the "Joinsville Island Area". Longitude is West and latitude is South.

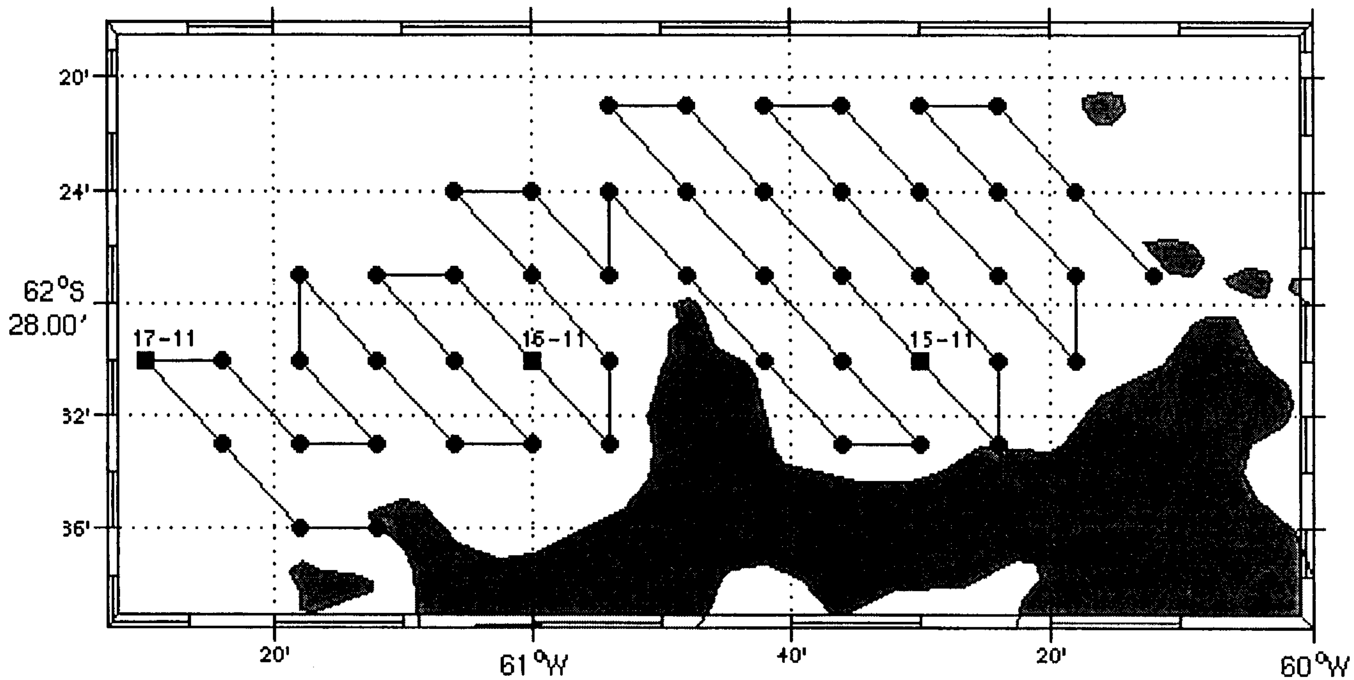
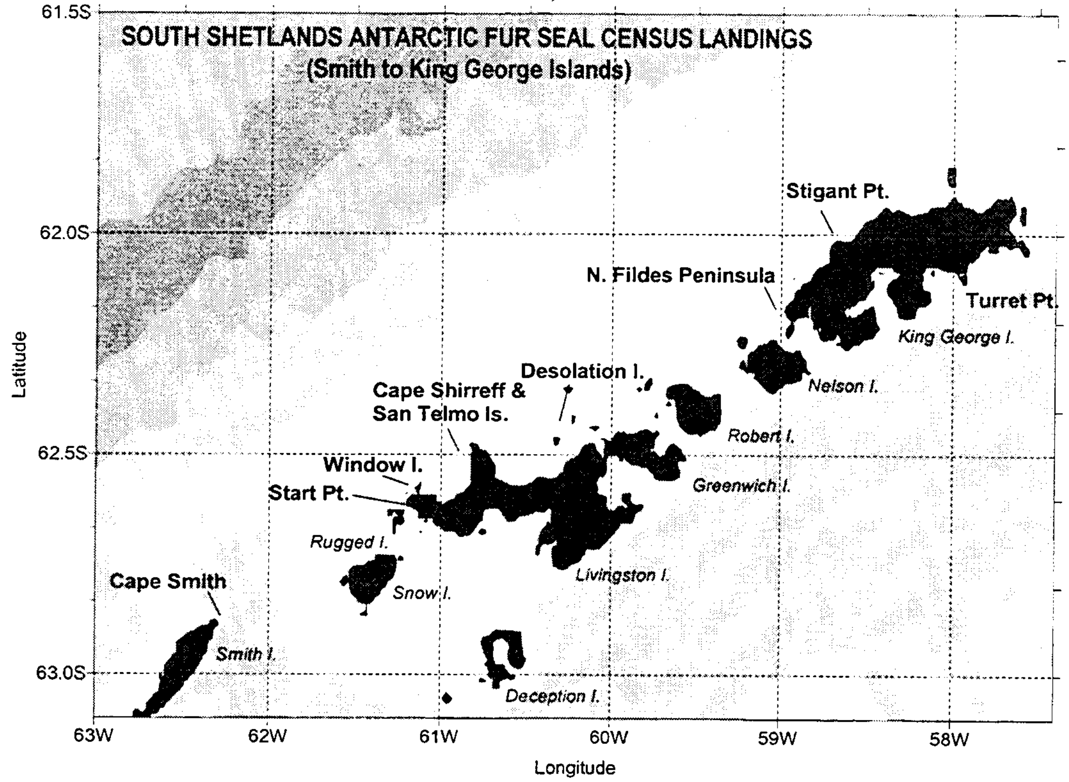


Figure 3. Cape Shirreff Survey, R/V *Ernest* transects and stations.

A)



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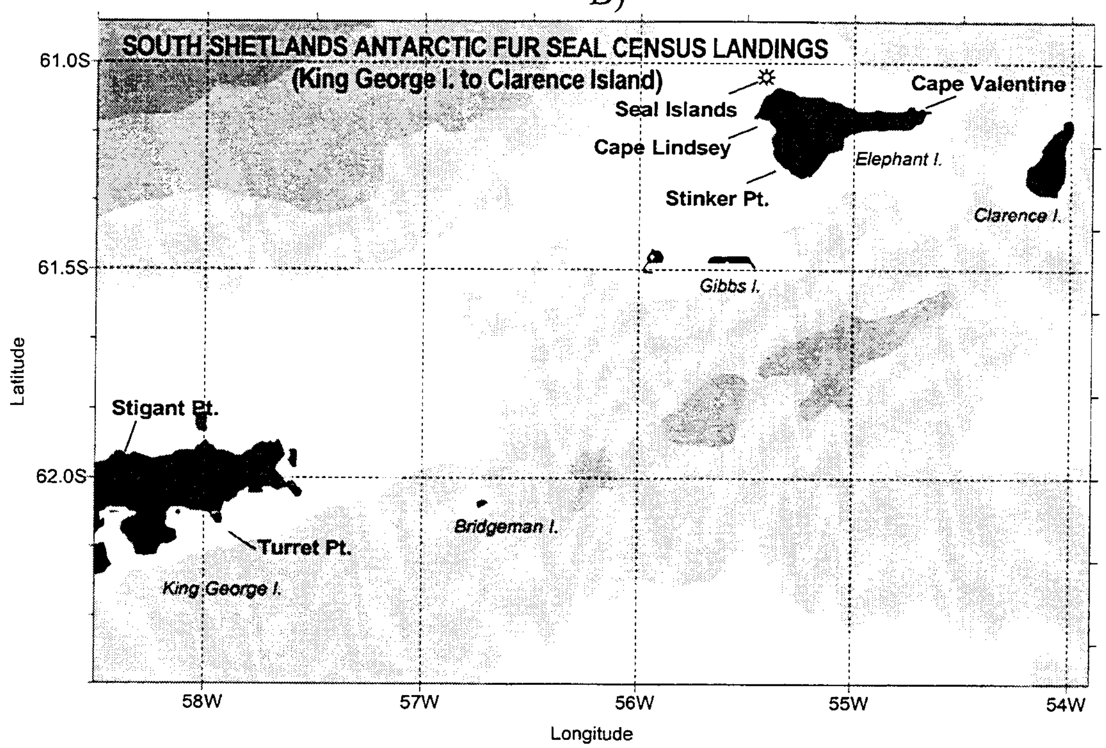


Figure 4. Known fur seal breeding colonies (n=13) in the South Shetland Islands, A) Smith Island to King George Island, and B) King George Island to Elephant Island.

OBJECTIVES

Shipboard Research:

1. Conduct a survey in the AMLR study area during Legs I and II to map meso-scale features of the dispersion of krill, water mass structure, phytoplankton biomass and productivity and zooplankton constituents using the R/V *Yuzhmorgeologiya*.
2. Estimate abundance and dispersion of krill and krill larvae in the AMLR sturdy area.
3. Calibrate the shipboard acoustic system in Admiralty Bay, King George Island near the beginning of Leg I, and again at Admiralty Bay near the end of Leg II.
4. Conduct an Antarctic fur seal pup survey at selected sites around the South Shetland Islands to provide estimates of pup abundance and distribution.
5. Conduct a high-resolution survey for krill in the vicinity of Cape Shirreff using a specially equipped Zodiac for the inshore areas and the *Yuzhmorgeologiya* for the offshore areas.
6. Deploy two buoys, instrumented with acoustical sensors and buoy-to-shore telemetry in the vicinity of Cape Shirreff.
7. Collect multi-scattering total target strength (TTS) measurements of live animals.
8. Collect continuous measurements of the research ship's position, water depth, sea surface temperature, salinity, turbidity, fluorescence, air temperature, barometric pressure, relative humidity, and wind speed and direction.
9. Provide logistical support to two land-based field sites: Cape Shirreff (Livingston Island), and Copacabana field camp (Admiralty Bay, King George Island).

Land-based Research:

<u>Cape Shirreff</u>

1. Estimate chinstrap and gentoo penguin breeding population size.
2. Band 1,000 chinstrap and 200 gentoo penguin chicks for future demographic studies.
3. Record at sea foraging locations for chinstrap penguins during their chick-rearing period using ARGOS satellite-linked transmitters (PTT's).
4. Determine chinstrap and gentoo penguin breeding success.
5. Determine chinstrap and gentoo penguin chick weights at fledging.
6. Determine chinstrap and gentoo penguin diet composition, meal size, and krill length/frequency distributions via stomach lavage.
7. Determine chinstrap and gentoo penguin breeding chronologies.
8. Deploy time-depth recorders (TDR's) on chinstrap and gentoo penguins during chick rearing for diving studies.
9. Collect data on foraging locations (using PTT's) and foraging depths (using TDR's) of chinstrap penguins while concurrently collecting acoustically derived krill biomass and location data during the inshore survey.
10. Deploy PTT's on chinstrap penguins following adult molt to determine migration routes and winter foraging areas in the Scotia Sea region.
11. Document Antarctic fur seal pup production for Cape Shirreff and assist Chilean

colleagues with censuses of fur seal pups for the entire Cape and the San Telmo Islands.

12. Monitor female Antarctic fur seal attendance behavior.
13. Collaborate with Chilean researchers in collecting Antarctic fur seal pup length, girth, and mass for 100 pups every two weeks through the season.
14. Collect 10 Antarctic fur seal scat samples every week for diet studies.
15. Collect a milk sample at each female Antarctic fur seal capture for fatty acid signature analysis and diet studies.
16. Record at-sea foraging locations for female Antarctic fur seals using Platform Terminal Transmitters (PTT).
17. Deploy time-depth recorders (TDR) on female Antarctic fur seals for diving studies.
18. Measure at-sea metabolic rates and foraging energetics of lactating Antarctic fur seals using doubly-labeled water.
19. Tag 500 Antarctic fur seal pups for future demographic studies.
20. Measure metabolic rates and thermo-neutral zones of pups and juvenile Antarctic fur seals using a metabolic chamber.
21. Collect teeth from selected Antarctic fur seals for age determination and other demographic studies.
22. Deploy a weather station for continuous recording of wind speed, wind direction, ambient temperature, humidity, and barometric pressure.

DESCRIPTION OF OPERATIONS

Shipboard Research:

For the seventh consecutive year, the cruise was conducted aboard the chartered Russian research vessel R/V *Yuzhmorgeologiya*.

Itinerary

Leg I:	Depart Punta Arenas	11 January 2002
	Resupply Cape Shirreff camp	14 January
	Calibrate in Admiralty Bay, King George Island	15 January
	Large-area survey (Survey A)	16-30 January
	Fur seal pup survey	31 January- 08 February
	Transfer personnel to Cape Shirreff	06 February
	Arrive Punta Arenas	12 February
Leg II:	Depart Punta Arenas	14 February
	Transfer personnel and supplies at Cape Shirreff	17 February
	Buoy deployment and Ernest calibration	17 February
	Cape Shirreff inshore survey	17-23 February
	Large-area survey (Survey D)	24 February- 08 March
	Close Cape Shirreff	10 March
	Close Copacabana and Calibrate in Admiralty Bay	11 March
	Arrive Punta Arenas	16 March

Leg I

1. The R/V *Yuzhmorgeologiya* departed Punta Arenas, Chile via the eastern end of the Strait of Magellan and proceeded to Admiralty Bay, King George Island to deliver supplies and personnel to the field camp.

2. The acoustic transducers were calibrated in Admiralty Bay, King George Island. The transducers, operating at 38 kilohertz (kHz), 120kHz, and 200kHz, were hull-mounted and down-looking. Standard spheres were positioned beneath the transducers via outriggers and monofilament line. The beam patterns were mapped, and system gains were determined.

3. The ship visited the Cape Shirreff and the Copacabana field camps to deliver provisions and supplies in the beginning of Leg I.

4. Survey components included acoustic mapping of zooplankton, direct sampling of zooplankton, Antarctic krill demographics, physical oceanography and phytoplankton observations were obtained. A large-area survey of 95 Conductivity-Temperature-Depth (CTD) and net sampling stations, separated by acoustic transects, was conducted in the vicinity of Elephant, Clarence, King George, and Livingston Islands (Survey A, Figure 3). Stations are located in four areas: stations to the west of Livingston and King George Islands are designated the "West Area," those to the south of King George Island are designated the "South Area," those around Elephant Island are called the "Elephant Island Area" and those south of Elephant Island are called the "Joinsville Island Area". Acoustic transects were conducted at 10 knots, using hull-mounted 38kHz, 120kHz, and 200kHz down-looking transducers. Operations at each station included: (a) vertical profiles of temperature, salinity, and oxygen, and measurements of chlorophyll at 5 meters depth; and (b) deployment of an IKMT to obtain samples of zooplankton and micronekton.

5. Optical oceanographic measurements were conducted, which included weekly SeaWiFS satellite images of surface chlorophyll distributions and *in-situ* light spectra profiles.

6. Continuous environmental data were collected throughout Leg I, which included measurements of ship's position, sea surface temperature and salinity, fluorescence, air temperature, barometric pressure, relative humidity, wind speed, and wind direction.

7. An Antarctic fur seal pup survey was conducted at selected sites throughout the South Shetland Islands at the end of Leg I.

8. The ship returned to Punta Arenas via the western end of the Strait of Magellan at the end of Leg I.

Leg II

1. The R/V *Yuzhmorgeologiya* departed Punta Arenas, Chile and proceeded to Cape Shirreff to deliver supplies and personnel to the field camp.

2. A high-resolution survey for krill and oceanographic conditions was conducted in the vicinity of Cape Shirreff (Figure 2). A specially-outfitted Zodiac, R/V *Ernest*, conducted a series of acoustic transects, CTD deployments and underwater video observations within 15 miles of Cape Shirreff. The ship complemented these measurements on a coarser grid further offshore, deploying an Isaacs-Kidd Midwater Trawl (IKMT).

3. Total target strength measurements (TTS) were conducted at Cape Shirreff using live zooplankton from the IKMT sample. Following acoustic measurements, morphometric measurements were made and animals photographed.

4. An instrumented buoy was deployed in the near-shore area of Cape Shirreff in water shallower than 100m. The buoy radio-telemetered data to a monitoring station at Cape Shirreff and was recovered at the end of Leg II.

5. A large-area survey of 95 Conductivity-Temperature-Depth (CTD) and net sampling stations, separated by acoustic transects, was conducted in the vicinity of Elephant, Clarence, King George, and Livingston Islands (Survey D, Figure 2). Stations are located in four areas: stations to the west of Livingston and King George Islands are designated the "West Area," those to the south of King George Island are designated the "South Area," those around Elephant Island are called the "Elephant Island Area" and those south of Elephant Island are called the "Joinsville Island Area". Acoustic transects were conducted at 10 knots, using hull-mounted 38kHz, 120kHz, and 200kHz down-looking transducers. Operations at each station included: (a) vertical profiles of temperature, salinity, and oxygen, and measurements of chlorophyll at 5 meters depth; and (b) deployment of an IKMT to obtain samples of zooplankton and micronekton.

6. Optical oceanographic measurements were conducted, which included weekly SeaWiFS satellite images of surface chlorophyll distributions and *in-situ* light spectra profiles.

7. As on Leg I, continuous environmental data were collected throughout Leg II.

8. At the end of Leg II, the ship then transited to Cape Shirreff to embark personnel and close the field camp.

9. Following the completion of the close of Cape Shirreff, the acoustic transducers were calibrated in Ezcurra Inlet, Admiralty Bay, and King George Island. The Copacabana field camp was closed and field personnel were retrieved.

10. The ship returned to Punta Arenas at the end of Leg II.

Land-based Research:

Cape Shirreff

1. A four-person field team (M. Goebel, J. Lyons, I. Saxer and D. Scheffler) arrived at Cape Shirreff, Livingston Island, on 14 November 2001 via the R/V *Nathaniel B. Palmer*. Equipment and provisions were also transferred from the R/V *Nathaniel B. Palmer* to Cape Shirreff.

2. Two additional personnel (R. Holt and B. Parker), along with supplies and equipment, arrived at Cape Shirreff via the R/V *Yuzhmorgeologiya* 16 January 2002. One person (W. Trivelpiece) arrived at Cape Shirreff on 5 February 2002 following the completion of the South Shetland Island fur seal pup survey.

3. The annual census of active gentoo penguin nests was conducted on 23 and 24 November 2001, and a similar census of chinstrap penguin nests was completed on 29 November and 1 December 2001. Reproductive success was studied by following a sample of 100 chinstrap penguin pairs and 50 gentoo penguin pairs from egg laying to crèche formation.

4. Radio transmitters were attached to 19 chinstrap penguins in the first week of January 2002 and remained on until their chicks fledged in late February 2002. These instruments were used to determine foraging trip duration during the chick-rearing phase. All data were received and stored by a remote field computer set up at the bird observation blind.

5. Ten satellite-linked transmitters (PTT's) were deployed on adult chinstrap penguins feeding chicks in late January to coincide with the time when the annual AMLR 2001/02 marine survey was adjacent to Cape Shirreff during Leg I. Four PTT's were deployed on gentoo penguins in mid-February to coincide with the AMLR near-shore hydroacoustic survey off Cape Shirreff.

6. Diet studies of chinstrap and gentoo penguins during the chick-rearing phase were initiated on 6 January 2002 and continued through 18 February 2002. Chinstrap and gentoo adult penguins were captured upon returning from foraging trips, and their stomach contents were removed by lavaging.

7. Counts of all gentoo penguin chicks were conducted on 20 January and 3 February 2002, and for chinstrap penguin chicks on 8 and 9 February 2002. Fledging weights of 256 chinstrap penguin chicks were collected between 15 and 23 February 2002. Two hundred gentoo penguin chicks were also weighed on 25 January and 7 February 2002.

8. Five hundred chinstrap penguin chicks and 200 gentoo penguin chicks were banded for future demographic studies.

9. Reproductive studies of brown skuas and kelp gulls were conducted through out the season at all nesting sites around the Cape.

10. Time-depth recorders (TDRs) were deployed on 8 chinstrap penguins for 10-12 days in mid-January to coincide with the marine sampling offshore at Cape Shirreff at the end of Leg I and beginning of Leg II.

11. Antarctic fur seal pups and female fur seals were counted at four main breeding beaches every other day from 18 November 2001 through 10 January 2002.

12. Attendance behavior of 28 lactating female Antarctic fur seals was measured using radio transmitters. Females and their pups were captured, weighed, and measured from 4-15 December 2001.

13. U.S. researchers assisted Chilean scientists in collecting data on Antarctic fur seal pup growth. Measurements of mass, length, and girth for 100 pups were begun on 16 December 2001 and continued every two weeks until 1 March 2002.

14. Information on Antarctic fur seal diet was collected using three different methods: scat collection, enemas of captured animals, and fatty-acid signature analyses of milk.

15. Twenty-four Antarctic fur seals were instrumented with time-depth recorders (TDR's) for diving behavior studies.

16. Thirteen Antarctic fur seal females were instrumented with ARGOS satellite-linked transmitters for studies of at-sea foraging locations from 23 December 2001 to 17 February 2002.

17. Four hundred and ninety-nine Antarctic fur seal pups were tagged at Cape Shirreff by U.S. and Chilean researchers for future demography studies.

18. A weather data recorders (Davis Instruments, Inc.) were set up at Cape Shirreff for wind speed, wind direction, barometric pressure, temperature, humidity, and rainfall.

19. A single post-canine tooth was extracted from 77 tagged female fur seals for aging and demography studies. Studies of the effects of tooth extraction on attendance and foraging behavior were initiated.

20. One team member (M. Goebel) left Cape Shirreff via the R/V *Yuzhmorgeologiya* on 30 January 2002.

21. The Cape Shirreff field camp was closed for the season on 10 March 2002; all U.S. personnel (R. Holt, W. Trivelpiece, B. Parker, I. Saxer, D. Scheffler and J. Lyons), garbage, and equipment were retrieved by the R/V *Yuzhmorgeologiya*.

SCIENTIFIC PERSONNEL

Cruise Leader:
- Roger P. Hewitt, Southwest Fisheries Science Center (Leg I)
- Adam Jenkins, Southwest Fisheries Science Center (Leg II)

Physical Oceanography:
- Derek Needham, Sea Technology Services (Legs I & II)
- Mark Prowse (Leg I)
- Mike Soule, Marine Radio Acoustic Devices (Leg II)

Phytoplankton:
- Christopher D. Hewes, Scripps Institution of Oceanography (Legs I & II)
- John Wieland, Scripps Institution of Oceanography (Leg I)
- Rick Reynolds, University of Washington (Leg I)
- Susana Giglio (Leg II)

Bioacoustic Survey:
- Jennifer H. Emery, Southwest Fisheries Science Center (Legs I & II)
- Roger P. Hewitt, Southwest Fisheries Science Center (Leg I)

Krill and Zooplankton Sampling:
- Valerie Loeb, Moss Landing Marine Laboratories (Legs I & II)
- Emma Bredesen, University of British Columbia (Legs I & II)
- Michael Force (Legs I & II)
- Nancy Gong, University of California at Santa Cruz (Legs I & II)
- Adam Jenkins, Southwest Fisheries Science Center (Legs I & II)
- Lorena Linacre-Rojas, CICESE (Legs I & II)
- Shelly Peters (Legs I & II)
- Rob Rowley, Moss Landing Marine Laboratories (Legs I & II)

Fur Seal Pup Survey:
- Rennie S. Holt, Southwest Fisheries Science Center (Leg I)
- Michael Goebel, Southwest Fisheries Science Center (Leg I)
- Verónica Vallejos, INACH (Leg I)
- Wayne Trivelpiece, Montana State University (Leg I)

Fur Seal Energetics Studies:
- Jessica D. Lipsky, Southwest Fisheries Science Center (Leg I)
- Anne Allen, Southwest Fisheries Science Center (Leg II)

Cape Shirreff Inshore Survey:
- David A. Demer, Southwest Fisheries Science Center (Leg II)
- Adam Jenkins, Southwest Fisheries Science Center (Leg II)
- Joe Warren, Southwest Fisheries Science Center (Leg II)
- Stephane Conti, Southwest Fisheries Science Center (Leg II)

Total Target Strength Measurements:

David A. Demer, Southwest Fisheries Science Center (Leg II)
Stephane Conti, Southwest Fisheries Science Center (Leg II)

Multi-Instrumented Buoy Project:

David A. Demer, Southwest Fisheries Science Center (Leg II)
Derek Needham, Sea Technology Services (Leg II)
Mike Soule, Marine Radio Acoustic Devices (Leg II)

Cape Shirreff Personnel:

Michael E. Goebel, Southwest Fisheries Science Center (11/14/01 to 1/30/02)
John Lyons (11/14/01 to 3/10/02)
Iris Saxer (11/14/01 to 3/10/02)
Dana Scheffler (11/14/01 to 3/10/02)
Rennie S. Holt, Southwest Fisheries Science Center (1/16/02 to 3/10/02)
Brian Parker, Southwest Fisheries Science Center (1/16/02 to 3/10/02)
Wayne Trivelpiece, Montana State University (2/6/02 to 3/10/02)

DETAILED REPORTS

1. Physical Oceanography and Underway Environmental Observations; submitted by Mark R. Prowse (Leg I), Derek J. Needham (Legs I & II), Michael A. Soule (Leg II) and David A. Demer (Leg II).

1.1 Objectives: Objectives were to 1) collect and process physical oceanographic data in order to identify and map oceanographic frontal zones; and 2) collect and process environment data underway in order to describe sea surface and meteorological conditions experienced during the surveys. These data may be used to describe the physical circumstances associated with various biological observations as well as provide a detailed record of the ship's movements and the environmental conditions encountered.

1.2 Accomplishments:

1.2.1 CTD/Carousel Stations: Ninety-two of the 95 planned CTD/carousel casts were made on Leg I (Survey A, Stations A15-15 to A14-12) with 3 casts being cancelled because of bad weather (Stations, A15-09, A14-10 and A13-09). An additional 4 casts (Survey prefix B) were done during the *ad hoc* survey north of Cape Sherriff after the main survey was completed during Leg I. An additional "blue water" cast (Station BWZ) was done at 61° 08'S during the transit north at the end of Leg I.

A total of 95 casts were completed during the main Leg II survey (Survey D). An additional 21 casts were performed between the 18th and 23rd February 2002 during the Near Shore Survey north of Cape Shirreff, Livingston Island. A single "blue water" cast (Station CWZ) was done at 58° 55.9'S during the transit from Punta Arenas to the survey area at the beginning of Leg II. Water samples were collected at discrete depths on all casts and used for salinity verification and phytoplankton analysis and these were drawn from the Niskin bottles by the Russian scientific support team. See Figure 2 in Introduction section for station locations. The Guildline Autosal difficulties experienced last year repeated themselves again during Leg I, despite the recent servicing of the unit. Sample readings were unstable and showed a random increase with time that could not be corrected. Samples from a representative cross-section of stations and depths were retained for later analysis. The faulty unit was replaced with a spare unit during the changeover between Legs I and II in Punta Arenas. This unit was also found to be unreliable and necessitated the retention of samples for later analysis. Comparison of the Seabird TSG salinity data with 7m CTD salinity data showed very good agreement, while the sea temperature showed the TSG to be 0.64°C higher than the CTD 7m data. This agrees with the 0.6°C measured in previous years and can be attributed to the internal positioning of the temperature sensor and heating effects of the seawater pump.

A comparison of the dissolved oxygen levels in the carousel water samples and the levels measured during the casts (via the O_2 sensor) was not attempted.

1.2.2 Underway Environmental Observations: Environmental and vessel positional data was collected for a total of 32 and 28 days for Legs I and II respectively via the Scientific Computer

System (SCS) software package (Software Version 3.2) running under Windows 2000 on a Pentium III (450mHz) PC. A Coastal Environmental Company Weatherpak system was installed on the port side of the forward A-frame in front of the bridge and was used as the primary meteorological data acquisition system. The data provided covered surface environmental conditions encountered over the entire AMLR survey area for the duration of the cruise including transits to and from Punta Arenas.

1.3 Methods:

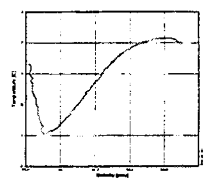
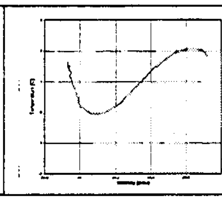
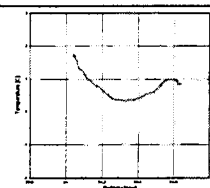
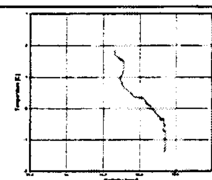
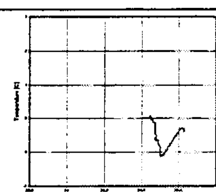
1.3.1 CTD/Carousel: Water profiles were collected with a Sea-Bird SBE-9/11+ CTD/carousel water sampler equipped with 10 new Niskin sampling bottles. An eleventh older bottle was added to the carousel to accommodate increased surface water (5 meters) volume requirements for phytoplankton analysis at selected stations. At these stations, this bottle was rigged to the same trigger as the 10th bottle to ensure that they closed simultaneously. On routine stations the 11th bottle allowed for an additional 15m sample to be collected. Profiles were limited to a depth of 750 meters or 5 meters above the sea bottom when shallower. A Data Sonics altimeter was used to stop the CTD above the bottom on the shallow casts. Standard sampling depths were 750m, 200m, 100m, 75m, 50m, 40m, 30m, 20m, 15m, 10m and 5m, except when two 5m samples were collected and the 15m sample was skipped. A Sea-Bird Dissolved Oxygen (DO) sensor (SeaBird, Model 13-02-B), two fluorometers (Wetlabs), two transmissometers (Wetlabs, CStar), one red and one blue spectrum and a PAR sensor (Biospherical 2pi) provided additional water column data during Legs I and II. Scan rates were set at 24 scans/second during both down and upcasts. Sample bottles were only triggered during upcasts. Plots of the down traces were generated and stored with the CTD cast log sheets. A second plot and an enlarged 0-300m plot was provided to the phytoplankton group, together with CTD mark files (reflecting data from the cast at bottle triggering depths) and processed up and down traces. Data from casts were averaged over 1m bins and saved separately as up and down traces during post processing. The data were logged and bottles triggered using Seabird Seasave Win32 Vs 5.22 and the data processed using SBE Data Processing Vs 5.22. The new dual screen configuration of the PC and the improvements to Seasave allowed additional windows of information to be displayed during the CTD casts, which greatly improved the information available to the operator (this included real-time T-S plots). Downcast data was re-formatted using a SAS script and then imported into Ocean Data View for further analysis.

1.3.2 Underway Data: Weather data inputs were provided by the Coastal Environmental Systems Company Weatherpak via a serial link and included relative wind speed and direction, barometric pressure, air temperature and irradiance (PAR). The relative wind data were converted to true speed and true direction by the internally derived functions of the SCS logging software. Measurements of sea surface temperature and salinity output in a serial format by the SeaBird SBE21 thermosalinograph (TSG) were also integrated into the logged data. Ships' position and heading were provided in NMEA format via a Furuno GPS Navigator and Magnavox MX 200 respectively. No underway transmissometer and fluorometer measurements were made during the routine survey. However an underwater transmissometer unit was experimentally interfaced via the Fluke Data Bucket A/D converter to the seawater flow-through line downstream of the Seabird TSG. Unfortunately bubble formation interfered with the data quality. Serial data lines were interfaced to the logging PC via a Digi-ports 16/EM serial multiplexor.

1.4 Results and Tentative Conclusions:

1.4.1 Oceanography: The position of the polar frontal zone, identified mostly by sea temperature change and minor salinity variation, was located from underway logged data during all 4 transits to and from Punta Arenas and the South Shetland Island survey area. This zone is normally found between 57-58°S. During the south transit for Leg I, the front was centred around 58° 30'S (encompassed by 58-59°S), shifting further south and becoming less clearly delineated between 60°S to 61° 30'S on the north-bound transit. The latter is possibly due to the more westward crossing of the Drake Passage (approximately 70°W compared with the 68°W southward transit). On the southbound transit for Leg II it had shifted further north between 57° 30'S and 58° 40'S. On the return northbound transit at the end of Leg II the zone had compressed and lay between 57° 20'S and 57° 50'S (Figure 1.1). As in previous years an attempt was made to group stations with similar temperature and salinity profiles into five water zones as defined in Table 1.1. While these classifications could generally be adhered to, the occurrence of Zone I water was less than expected during Legs I and II. While the southern boundary of the Antarctic Circumpolar Current (SB-ACC) was clearly delineated within the survey area by the presence of the 1.8°C isotherm and the 4.1mL/L dissolved oxygen level (markers defined by Hofmann *et al.*, 1996), the T-S curves of the CTD casts north of this boundary were not conclusively Zone I water. Current screening criteria specify the salinity at minimum temperature (approximately –1.0°C) should be 34.0 ppt, but during Leg I only 3 stations in the offshore western area met this criteria. While conforming to the general T-S shape, most other Zone I stations with similar characteristics had higher salinities at the temperature minimum. In comparing the data of 2000/01 and 2001/02, the normal winter water (WW) sub-surface minimum was neither as extensive, nor as cold during 2001/02, possibly a result of poor sea-ice development in preceding winters (Hewitt, R.P. pers. comms; Hewitt, R.P., 1997). Water Zones II and III were identified in the southwest to northeast axis of the survey area with a clear meandering of both Zone II water and the SB-ACC into the north-east in the area north of Elephant Island. Zone IV water can be seen extending from within the Bransfield Strait (south of Livingston Island) past King George Island, narrowing and passing south of Elephant Island and being pushed north of Clarence Island by the Zone V intrusion from the southeast. Zone V water dominates the extreme southeast of the area, intruding into the coastal-shelf area of the south Bransfield Strait. It is the tentative conclusion that while the southern area conforms to expectations, the northern area of the survey is dominated by transitional water and that the normal extent of Zone I intrusion from the northwest was reduced this season. This was also evident during Leg II where the SB-ACC appeared to have shifted northwards particularly in the northeast of the survey area. Note that although stations over the shelf regions were classified as Zone III, reduced data sets (resulting from the shallower water encountered) introduced a degree of uncertainty into the precision of Zone allocations.

Table 1.1. Water Zone definitions applied for Legs I and II, AMLR 2001/02.

	T/S Relationship			
	Left	**Middle**	**Right**	**Typical TS Curve (from 2001/02)**
Water Zone I (ACW)	**Pronounced V shape with V at ≤0°C**			
Warm, low salinity water, with a strong subsurface temperature minimum, Winter Water, approx. -1°C, 34.0ppt salinity) and a temperature maximum at the core of the CDW near 500m.	2 to >3°C at 33.7 to 34.1ppt	≤0°C at 33.3 to 34.0 ppt	1 to 2°C at 34.4 to 34.7ppt (generally >34.6ppt)	
Water Zone II (Transition)	Broader U-shape			
Water with a temperature minimum near 0°C, isopycnal mixing below the temperature minimum and CDW evident at some locations.	1.5 to >2°C at 33.7 to 34.2ppt	-0.5 to 1°C at 34.0 to 34.5ppt (generally >0°C)	0.8 to 2°C at 34.6 to 34.7ppt	
Water Zone III (Transition)	Backwards broad J-shape			
Water with little evidence of a temperature minimum, mixing with Zone II transition water, no CDW and temperature at depth generally >0°C	1 to >2°C at 33.7 to 34.0ppt	-0.5 to 0.5°C at 34.3 to 34.4ppt (note narrow salinity range)	≤1°C at 34.7ppt	
Water Zone IV (Bransfield Strait)	Elongated S-shape			
Water with deep temperature near -1°C, salinity 34.5ppt, cooler surface temperatures.	1.5 to >2°C at 33.7 to 34.2ppt	-0.5 to 0.5 °C at 34.3 to 34.45ppt (T/S curve may terminate here)	<0°C at 34.5ppt (salinity < 34.6ppt)	
Water Zone V (Weddell Sea)	Small fish-hook shape			
Water with little vertical structure and cold surface temperatures near or < 0°C.	1°C (+/- some) at 34.1 to 34.4ppt	-0.5 to 0.5°C at 34.5ppt	<0°C at 34.6ppt	

The MATLAB program written during AMLR 2000/01 was used in an attempt to reduce any subjective influence on the classification of water types (see AMLR 2000/01 Field Season Report, Chapter 1 for details). Although the program was essentially a fairly coarse first attempt to classify water zones in the survey area, it supported the contention that Zone I water is less prevalent in the northwest and provides a valuable objective confirmation. The distinction between Zone IV and V water in the southeastern quadrant seemed less robust and it did not agree well with the visually allocated classifications (Figure 1.2). Further refinements, possibly broadening the range of criteria used, may be required for this part of the algorithm. Vertical temperature profiles generated from CTD data on transects W05, EI03, and EI07 (Figure 1.3) show an apparent influx of warmer surface water during Leg II.

1.4.2 Underway Data: Environmental data was recorded for the duration of both Legs I and II and for the transits between Punta Arenas and the survey area (except for TSG data which is not available for transits in the Strait of Magellan). Very short periods of data were lost periodically while the logging PC was routinely reset. Processed data were averaged and filtered over 5-minute intervals to reduce the effects of transients, particularly in data recorded from the thermosalinograph, which was sometimes prone to the effects of aeration (Figures 1.4 & 1.5).

Comparisons between the weather conditions experienced during Legs I and II during the surveys show significant differences, primarily between wind direction and PAR readings (Figures 1.4 & 1.5).

During Leg I the wind blew predominantly from the west (southwest and northwest) with occasional short spells of easterlies, peaking to 20 knots. During Leg II recorded wind speeds averaged less than Leg I, the wind blowing mainly from the north and northeast. Short periods of southerly winds were also recorded (Figure 1.6).

The mean air temperatures generally remained above zero for both Legs, with the lowest recorded survey temperature of approx. -1°C occurring on the 7th March during Leg II.

Weather for Leg I was most often partly-cloudy or overcast, a number of days of poor visibility and some fog were experienced and a few light snowfalls were recorded, including one shortly after commencing the northbound Drake crossing. Conditions were similar during Leg II with the PAR sensor indicating reduced levels of photosynthetic radiation. There was a noticeable reduction in the number of icebergs seen in the survey in comparison with the AMLR 2000/01 survey.

1.5 Disposition of Data: Data are available from Roger Hewitt, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA, 92037; phone/fax +1 (858) 546-5602/5608; email: Roger.Hewitt@noaa.gov.

1.6 Acknowledgements: The co-operation and assistance of the Russian technical support staff was always outstanding. All requests for assistance were dealt with efficiently and in a thoroughly professional manner.

1.7 Problems and Suggestions: At the start of Leg I, the "Sea Cable" fuse on the CTD deck unit blew when supplying CTD underwater unit S No. 0455. On dismantling the unit, the PSU was found to be faulty and it was returned to Seabird, U.S.A. for test and repair. The spare CTD unit (0454) was then used for Leg I. Corrosion of the Y-lead connector for the two Wetlabs Transmissometers attached to CTD bulkhead connector was detected when it was inspected after a change in data for transect EI07 was noted. One of the CTD connector pins was also corroded but serviceable. All pins on the bulkhead connector were cleaned and the interconnecting cable was replaced with a spare.

Prior to the start of the Leg II survey, the CTD underwater unit (S. No. 0913966-0454) was closely inspected and signs of leakage were clearly evident on a number of bulkhead connectors, the worst affected being the fluorometer and PAR channels. On opening unit 0454, evidence of corrosion was found in the vicinity of the "O-ring" seals. It is highly likely that the underwater casing will have to be replaced when the unit is next serviced. The underwater unit was therefore replaced at the start of Leg II with S. No. 0455 (the unit which was returned to Seabird for PSU repairs at the start of Leg I). The thermosalinograph worked well although data integrity was occasionally affected during periods of bad weather when excessive aeration occurred.

The Autosal Salinometer was again prone to apparent instability and it proved impossible, despite email assistance from the servicing agents, to accurately standardize the unit. Following the problems experienced last year the unit was serviced but the new thermocouple pairs installed to control the temperature bath temperature may not be to the required standard and will need to be tested. It is recommended that the unit again be returned to the manufacturers for service and calibration prior to the next cruise or that serious consideration be given to the acquisition of a new, current technology unit since the existing unit is more than 20 years old. A replacement unit obtained for Leg II failed after a short period and selected water samples had to be retained for later analysis.

The Coastal Environmental Systems Weatherpak originally installed (No. 798) was found to have a defective air pressure sensor during initial setup. The faulty unit was opened and inspected and a plug on the sensor circuitry was found to be partially disconnected and the pins badly bent, probably a result of impact with the casing during re-assembly after annual servicing by the agents. The fault was repaired and the unit was deployed on R/V *Ernest*. The spare unit (No. 797) was fitted on the R/V *Yuzhmorgeologiya* and this worked reliably for the full duration of Legs I and II of the cruise. The overscale humidity values (up to 110%), which occurred whenever rainy or foggy conditions arose during the survey, are most likely due to saturation of the sensor.

The CTD/SCS logging PC, currently a Pentium 450mHz, required periodic re-booting to eliminate a gradual slowing of the system. This slowing resulted in delayed bottle triggering response times and small deviations from the preferred sampling depths. The Windows-based Seabird data capture program Seasave and SBE Data Processing suite were used for logging and processing respectively. Since the slow-down was not noted last season when the same PC was used for DOS-based Seabird programs, it is suspected that the new software versions utilise a greater percentage of system resources causing the system to become sluggish over extended periods of time. It was noted that when processing was being done in the background and a cast was initiated, overflow errors resulted. Eventual upgrade to a faster processor should be considered.

1.8 References:

Hewitt, R.P. 1997. Areal and seasonal extent of sea-ice cover off the northwestern side of the Antarctic Peninsula: 1979 to 1996. *CCAMLR Science* 4: 65-73.

Hofmann, E.E., Klinck, J.M., Lascara C.M., and Smith, D.A. 1996. Water mass distribution and circulation west of the Antarctic Peninsula and including Bransfield Strait. *In*: Ross, R.M., Hofmann, E.E., and Quetin, L.B. (Editors). Foundations for Ecological Research West of the Antarctic Peninsula, American Geophysical Union, Washington DC, Antarctic Research Series 70, pp. 61-80.

Schlitzer, R. 2001. Ocean Data View. http://www.awi.bremerhaven.de/GEO/ODV.

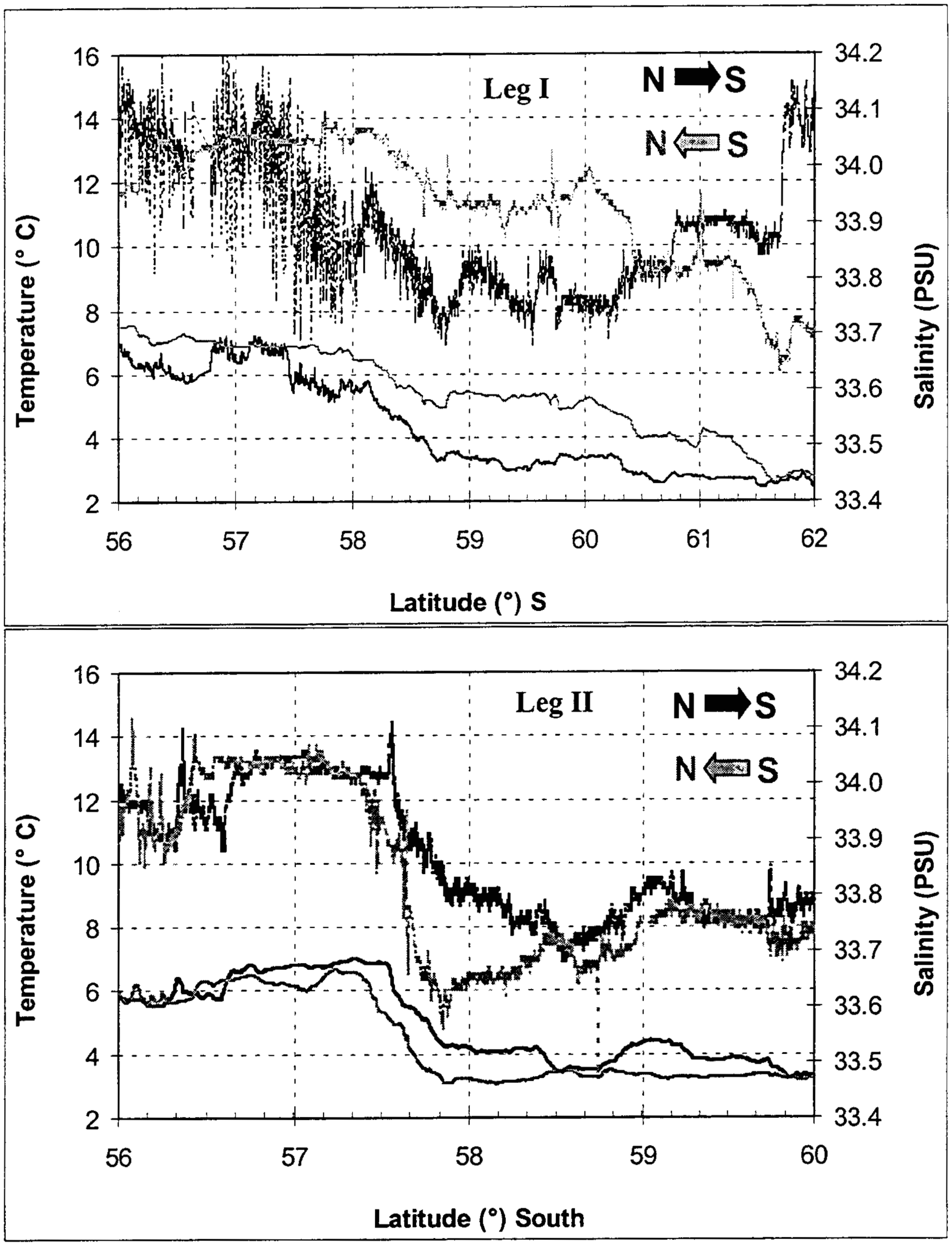


Figure 1.1. The position of the polar fronts as determined for AMLR 2001/02 Legs I (top) and II (bottom), from measurements of sea surface temperature (solid line) and salinity (broken line) for the south and north transits to and from the South Shetland Islands survey area.

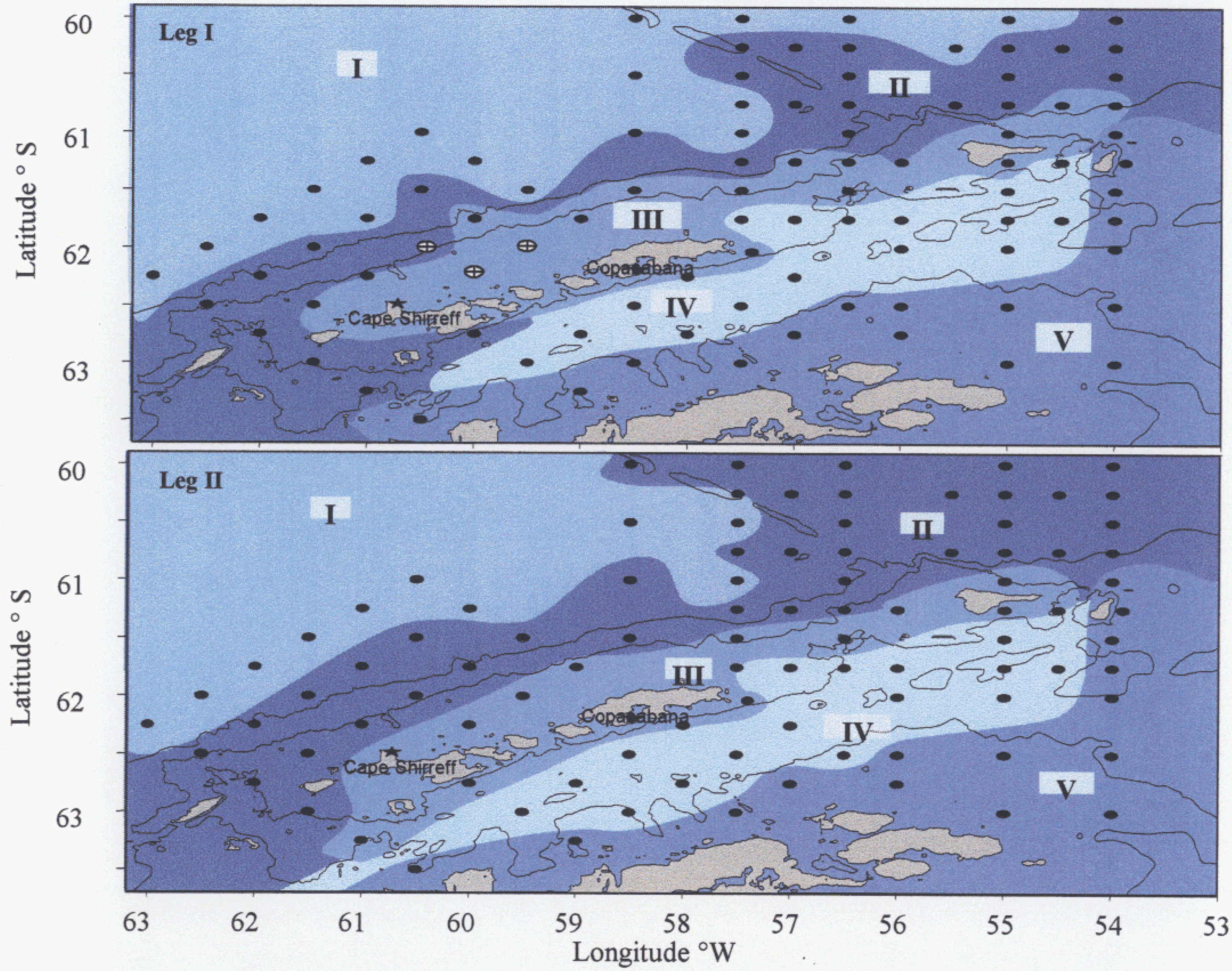


Figure 1.2. The five water zones derived from scrutinising T-S characteristics for Legs I (top) and II (bottom panel). Note that although stations over the shelf regions were classified as Zone III, the reduced data sets (resulting from the shallower water encountered), introduced a degree of uncertainty into the precision of the allocations. Stations aborted due to bad weather conditions (Leg I) are indicated by ⊕.

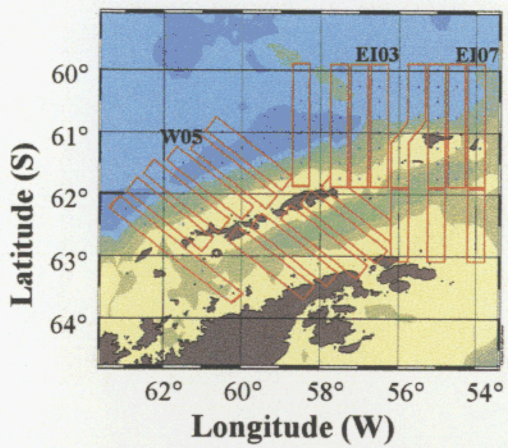
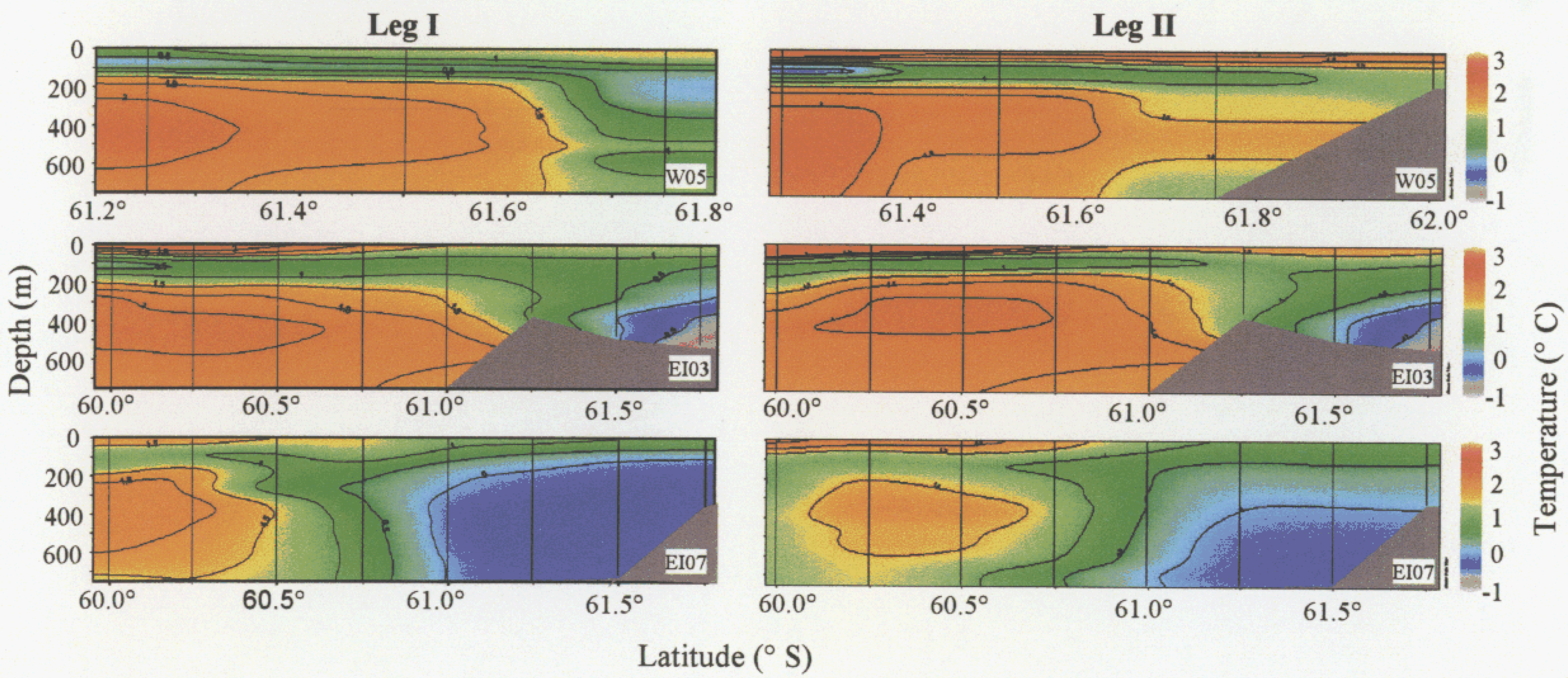


Figure 1.3. Vertical temperature profiles derived from CTD data recorded on three transects, W05 (top), EI03 (middle) and EI07 (bottom), during Legs I (left col.) and II (right col.) of the AMLR 2001/02 South Shetland Island survey. Note that station A13-09 (Leg I) was aborted due to bad weather.



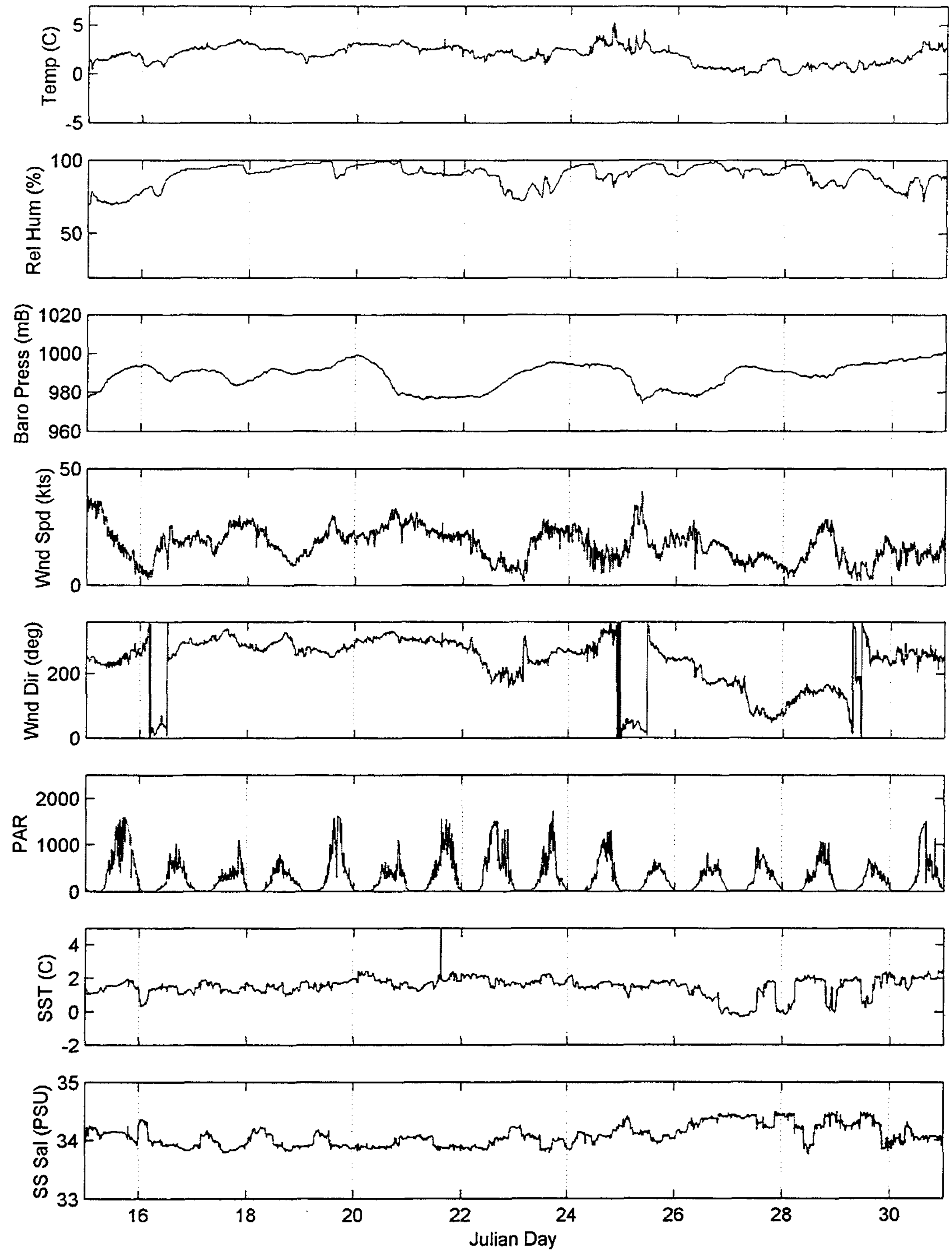


Figure 1.4. Meteorological data (5-minute averages) recorded between January 16th and January 29th during Leg I of the AMLR 2001/02 cruise. (PAR is photo-synthetically available radiation).

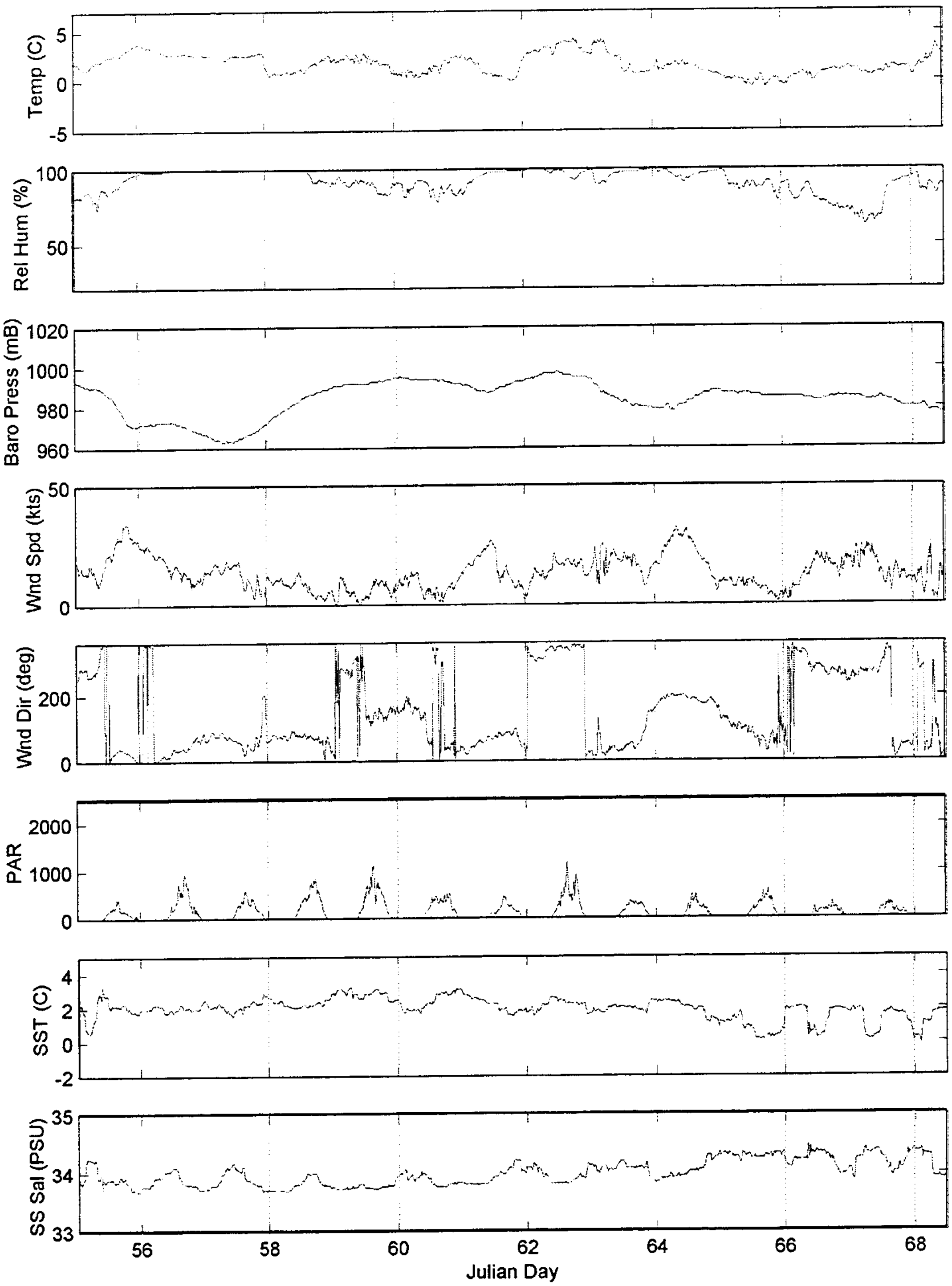
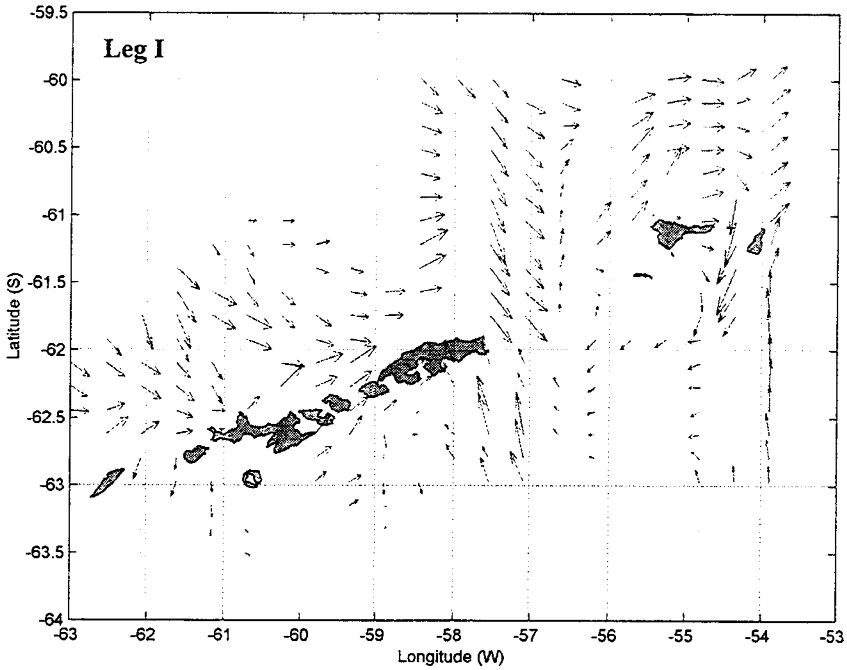


Figure 1.5. Meteorological data (5-minute averages) recorded between February 24th and March 9th during Leg II of the AMLR 2001/02 cruise. (PAR is photo-synthetically available radiation).



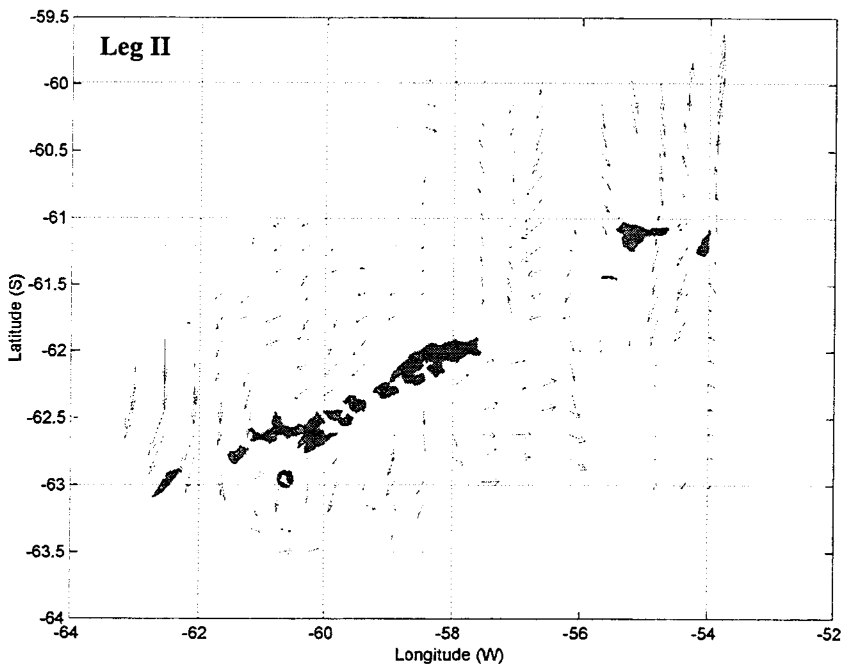


Figure 1.6. Vectors representing wind speed and direction for Legs I (top) and II (bottom) derived from data recorded by the SCS logging system during the AMLR 2001/02 survey of the South Shetland Islands.

2. Phytoplankton Distributions and Photophysiological States; submitted by Christopher D. Hewes (Legs I & II), John Wieland (Leg I), Rick Reynolds (Leg I), Susana B. Giglio (Leg II), B. Greg Mitchell, Mati Kahru, and Osmund Holm-Hansen (SIO).

2.1 Objectives: The overall objective of our research project was to assess the distribution and concentration of food reservoirs available to the herbivorous zooplankton populations throughout the AMLR study area during the austral summer. Specific objectives of our work was to determine the distribution and biomass of phytoplankton in the upper water column (surface to 200m), with emphasis on the upper 100m, and in conjunction with the NASA SIMBIOS program, (1) to measure pigment-specific absorption by total particulates, detritus and phytoplankton; (2) to measure the spectral attenuation of light with depth; (3) to coordinate these activities with SeaWiFS satellite coverage; (4) to calibrate satellite imagery of spectral reflectance to surface chlorophyll concentrations.

2.2 Methods and Accomplishments: The major types of data acquired during these studies, together with an explanation of the methodology employed, are listed below.

2.2.1 Sampling Strategy: The CTD carousel and independent profiling units were used to obtain samples of the water column for analyses as well as to obtain data from various profiling sensors as listed below:

(A) For both Legs, water samples were obtained from 10-liter Niskin bottles (with Teflon covered springs) which were closed at 5 meters for every station plus 9 other standard depths (10, 15, 20, 30, 40, 50, 75, 100, and 200m) from every station upcast of the CTD/rosette unit. An exception was made during Leg I when samples for bio-optical measures required larger volumes of water; at these stations, the 15-meter sample was omitted and two Niskin bottles were fired at 5 meters.

(B) For both Legs, two transmissometers (488 and 660nm wavelengths, Wetlabs C-star) were used to determine the attenuation of collimated light (by both scattering and absorption) during CTD casts.

(C) For both Legs, two profiling fluorometers (Wetlabs and SeaTek) were used to measure *in situ* chlorophyll fluorescence.

(D) For Leg I only, a bio-optical instrument package and free-fall profiling reflectance radiometer were deployed at selected CTD stations. These casts were made in conjunction with more detailed analysis of pigment and particulate content from a 5-meter Niskin bottle water sample.

2.2.2 Measurements and Data Acquired:

(A) Chlorophyll-*a* concentrations: Chl-*a* concentrations in the water samples were determined by measurement of chl-*a* fluorescence after extraction in an organic solvent. Sample volumes of 100mL were filtered through glass fiber filters (Whatman GF/F, 25mm) at reduced pressure (maximal differential pressure of 1/3rd atmosphere). The filters with the particulate material were placed in 10mL of absolute methanol in 15mL tubes and the photosynthetic pigments allowed to extract at 4°C for at least 12 hours. The samples were then shaken, centrifuged, and the clear supernatant poured into cuvettes (13 x 100mm) for measurement of chl-*a* fluorescence before and after the addition of two drops of 1.0 N HCl. Fluorescence was measured using Turner Designs Fluorometer model #700 having been calibrated using spectrophotometrically determined chl-*a* concentrations of a prepared standard (Sigma). Stability of the fluorometer was verified daily by use of a fluorescence standard.

(B) Miscellaneous optical and cellular measurements: For 31 stations during Leg I, discrete water samples were obtained between 1000 and 1600 GMT (corresponding with the time that SeaWiFS satellite observations of the area became available) for pigment analyses. Water bottle samples obtained at up to three discrete depths were used for each of the following analyses, for which 1-2 liters were filtered through 25mm Whatman GF/F filters:

- Particulate Absorption (a_p) and Soluble Absorption (a_s). Spectral absorption coefficients of particulate and soluble material were performed on a CARY 100 dual beam spectrophotometer.
- High Pressure Liquid Chromatography (HPLC). HPLC will be used for the analysis of various chlorophylls and associated pigments. Samples were frozen and stored in liquid nitrogen until their analyses can be made at SIO. Chlorophyll and associated pigments will be used to determine the proportions of algal classes contained in the phytoplankton community.
- Particulate Organic Carbon and Nitrogen (POC and PON). Whatman GF/F filters used for sample preparation were combusted at 450°C prior to the cruise. Samples were frozen and will be analyzed by standard gas chromatography methods at the analytical facility at UC Santa Barbara.
- Phycoerythrins (PE). Cryptomonads are a common phytoflagellate in the AMLR study region and are distinguished from other phytoplankton in the area by PE. The filtered water samples were frozen and stored in liquid nitrogen until their analysis at SIO. PE will be measured using a Spex Fluoromax spectrofluorometer.

(C) Several sensors were attached to the SeaBird CTD unit during both Legs I and II for measuring specific characteristics of the water column, and included:

1. Measurement of beam attenuation: Two single wavelength (488 and 660nm) C-star transmissometers (Wetlabs, Inc.) were placed on the Seabird CTD carousel for deployment at each station. Previous studies have shown that beam attenuation (660nm) coefficients can be used to estimate total particulate organic carbon in Antarctic waters (Villafañe *et al.*, 1993). This calculation assumes that there is a negligible load of inorganic sediment in the water, a condition that is apparently satisfied throughout the study area.

2. Measurement of chlorophyll fluorescence: Two profiling fluorometers were used to obtain measures of chlorophyll fluorescence intensity in the water column. These data are used (in conjunction with the measurement of photosynthetically active radiation, PAR) to estimate chlorophyll concentrations *in situ*, using the algorithm of Holm-Hansen *et al.* (2000) as applied specifically for the AMLR survey region.

3. A Biospherical Instruments cosine PAR (photosynthetically available radiation) sensor (Model #QCP-200L) to measure light attenuation profile in the water column. This sensor is also used in conjunction with the SeaTek fluorometer to estimate chlorophyll concentrations *in situ*, and to provide a parameter to measure the variability of photophysiological responses of phytoplankton.

(D) *In situ* optical oceanography: Corresponding approximately in time with the optimal time that the SeaWiFS satellite passed over, a Biospherical Instruments free-fall Profiling Reflectance Radiometer (PRR-800) was deployed. The PRR-800 measured spectral downwelling (E_d) and upwelling (E_u) irradiances and upwelling radiance (l_u) at 19 wavelengths continuously from the surface to the bottom of the profile. Profile depths ranged from 50-200 meters depending on the station. Spectral values of normalized water-leaving radiance will be computed from the PRR-800 data and used to validate SeaWiFS satellite data, as well as, to develop Southern Ocean regional ocean color algorithms.

(E) Seven deployments of an integrated optics package, consisting of a Fast Repetition Rate Fluorometer (FRRF, Chelsea Instruments, Inc.; Kolber *et al.*, 1994) to obtain photophysiological state of phytoplankton communities, and a Hydroscat 6 (HobiLabs, Inc.) to estimate the backscatter of light at 6 wavelengths from 440-700nm.

(F) Satellite Oceanography: SeaWiFS chlorophyll images were obtained for 8-day and monthly average composites from NASA archives (http://eosdata.gsfc.nasa.gov/). These data were sufficient to evaluate the time-dependence and distribution of chl-*a* within our study region.

(G) During the Seal Survey and through the end of Leg I, continuous measures of FRRF were made using the continuous flow system on board (refer to the Physical Oceanography section-Chapter 1 for details). These were complimented with 30 measurements of chlorophyll concentrations during the transect to Punta Arenas, Chile at the end of Leg I.

(H) Two opportunistic stations were made during the transect to Punta Arenas at the end of Leg I (Station BWZ or "blue water" station) and on the return to Cape Shirreff at the beginning of Leg II (Station CWZ). Station BWZ included CTD/PAR/Transmissometer/Fluorometer, PRR-800 and integrated optics package deployment, plus a suite of biological measurements (see items 1 and 2 above) from water samples taken by Niskin bottle. Station CWZ included CTD/PAR/Transmissometer/Fluorometer and chlorophyll measurements from water bottle samples.

(I) During the Near Shore Survey on the southwestern coast of Livingston Island during the beginning of Leg II, measurement of chlorophyll concentrations from the continuous flow system were made at 2-hour intervals.

2.3 Tentative Results and Conclusions:

2.3.1 Overview of phytoplankton distributions in the AMLR survey areas January-March: **Leg I** (refer to Figure 2.1A; see also Figure 2 in Introduction section for locations of the different areas and station position in the survey grid):

West Area. For the West Area, chlorophyll-*a* at 5m averaged 0.59 ± 0.29 mg m^{-3} (n = 23), and values integrated to 100m were 44 ± 18 mg m^{-2} (n = 25). For this area, chlorophyll concentrations during Leg I were average compared with previous years (5 meter being 0.63 ± 0.99 mg m^{-3} n = 131; 100m integrated being 34 ± 22 mg m^{-2}, n = 111). However, notable differences were observed. Stations located in waters less than 1,000 meters depth had concentrations of 0.72 ± 0.21 mg chlorophyll m^{-3} as compared with pelagic stations that had 0.83 ± 0.34 mg chlorophyll m^{-3} (last year coastal stations had much more chlorophyll than pelagic stations). In this regard, of interest is that the highest chlorophyll concentrations for Leg I in the West Area were located off the shelf in deeper waters (Stations A17-07 and A19-09 having > 1.0 milligram m^{-3} in near surface waters). The unusual pattern for chlorophyll distribution in the West Area for Leg I was also reflected in the physical oceanography data (see Physical Oceanography section, this volume). This will be discussed in more detail in section 2.3.3 below.

Elephant Island Area: The pattern for surface chlorophyll concentration in the Elephant Island sector followed the bottom topography of the area. Five-meter chlorophyll averaged 0.55 ± 0.28 mg m^{-3}, and integrated (100 meters) averaged 44 ± 19 mg m^{-2} for the entire section (42 stations). The shelf and break area around Elephant Island (14 stations) averaged 0.69 ± 0.32 mg chl m^{-3} as compared to 0.49 ± 0.25 mg chl m^{-3} in the oceanic region (22 stations). Chlorophyll concentrations this Leg were average compared with the 12 year Leg I mean (5 meter being 0.79 ± 0.79 mg m^{-3} n = 644; 100m integrated being 43 ± 35 mg m^{-2}, n = 591).

Joinville Island and South Areas: The pattern for surface chlorophyll concentrations in the Bransfield Strait (South Area) and Joinville Island Area closely follows the zones of water, with low values found for the Weddell Sea (Water Zone V) and high values for the Bransfield Strait (Water Zone IV). Five-meter chlorophyll averages 1.39 ± 0.88 mg m^{-3}, and integrated (100 meters) averages 67 ± 21 mg chl m^{-2} for the South Area (14 stations). The Bransfield Strait region closest to the Shetland Islands (7 stations) averaged 1.89 ± 1.00 mg chl m^{-3} as compared to 0.36 ± 0.27 mg chl m^{-3} for those stations closest to the peninsula (10 stations). The most phytoplankton rich area of the entire first Leg were for stations A11-11, A09-09 and A12-12 having highest 5 meter chlorophyll concentrations of 3.2, 2.3 and 2.7 mg m^{-3}, respectively. The lowest chlorophyll concentrations of the first Leg were found near the Weddell Sea (Stations A02-13, A04-11, and A04-13), having 0.08 ± 0.01 mg chl m^{-3}. For the South Area, chlorophyll concentrations this Leg were above average compared to previous years (5 meter being 1.30 ± 0.89 mg chl m^{-3} n = 63; 100m integrated being 51 ± 34 mg chl m^{-2}, n = 45).

Leg II (refer to Figures 2.1B and 2.1C):

Near Shore Survey (North of Livingston Island, 19-23 February, 2002): During the Near Shore Survey, chlorophyll samples were taken every hour from the continuous flow system (n = 78) in addition to bottle samples obtained during the 21 CTD casts (n = 197). Near surface chlorophyll concentrations ranged 0.14-1.82 mg m^{-3}, with waters along the shelf break (500-1,000 meter bottom depth) containing the greatest concentrations (Figure 2.1B). Only Stations C016 and C023 demonstrated chlorophyll maxima at 40-50 meters, while all other stations had generally uniform distributions to the thermocline.

West Area: Corresponding with more clear delineation of water zones during Leg II (refer to the physical oceanography section, this volume), chlorophyll at both horizontal and vertical scales approached more classical descriptions (Figure 2.1C; see Holm-Hansen *et al.*, 2000) with notable exceptions. For the West Area, chlorophyll concentrations at 5-meter depths for Water Zone I waters (furthest from the South Shetland and Elephant Islands) averaged 0.44 ± 0.28 mg m^{-3} (8 stations), Water Zone II waters averaged 1.15 ± 0.69 mg m^{-3} (10 stations), and Water Zones III (shelf-related) waters averaged 1.34 ± 0.69 mg m^{-3} (5 stations). Integrated values of chlorophyll (to 100 meters) were 32.3 ± 18.2, 67.7 ± 37.5 and 67.1 ± 25.9 mg m^{-2} for Water Zones I, II, and III respectively. Chlorophyll concentrations for Zone I waters had chlorophyll concentrations that were higher than classically described (generally less than 0.5 mg chl m^{-3} at 5m), and with nearly all stations lacking a chl maxima at and above the thermocline. For Leg II, chlorophyll concentrations for the West Area were 0.96 ± 0.73 mg m^{-3} for 5m samples and 54 ± 30 mg m^{-2} for integrated chlorophyll to 100m. For the roughly the same area, chlorophyll concentrations this Leg were above average compared previous years (5 meter being 0.64 ± 0.72 mg chl m^{-3} n = 94; 100m integrated being 40 ± 36 mg chl m^{-2}, n = 78).

Elephant Island Area: Five-meter chlorophyll averages for the Elephant Island Area were 0.97 ± 0.57 mg m^{-3}, and integrated (100 meters) averages 66 ± 36 mg m^{-2} for the entire Elephant Island Area (43 stations). These surface values are about 80% higher, while integrated values about 50% higher, than those found during Leg I (January). For this area, chlorophyll concentrations for Leg II were about the same as the 12-year average during Leg of 1.08 ± 1.23 mg chl m^{-3} (n = 445) for 5 meters and 61 ± 57 mg chl m^{-2} (n = 504) for 100m integrated values.

Joinville Island and South Areas: Phytoplankton biomass decreased over Leg I values for the South Area, with 5m chlorophyll values of 0.95 ± 0.47 mg m^{-3} and integrated values of 52 ± 22 mg chl m^{-2} (n = 25) represented by the South Area, but increased considerably for the Joinville Island area, with 1.06 ± 0.69 mg m^{-3} and 70 ± 29 mg m^{-2} (n = 9) for 5m and integrated (100m) chl, respectively. The South Area phytoplankton biomass for Leg II was considerably less than the 12-year average of 1.93 ± 1.91 mg chl m^{-3} for 5 meters and 110 ± 110 mg m^{-2} for integrated (100m) chlorophyll. Too few data have been collected in the Joinville Island Area to make any comparisons with previous years.

2.3.2 Opportunistic stations and survey work: The first opportunistic station (BWZ; 61° 15'S 68° 31'W) was done during the transect back to Punta Arenas at the end of Leg I (Figure 2.2). This station was both preceded and followed up with continuous measurements of phytoplankton biomass and physiology, temperature and salinity from the ship's continuous flow seawater system (Figure 2.3). At Station BWZ, the Antarctic Circumpolar Current had a broad temperature minimum that ranged between 75-160 meters. Although at 160 meters, temperature was -0.27°C and salinity was 34.02‰ to classify it as Water Zone I, this broad and deep range for the temperature minimum was different as compared to previous years. Chlorophyll of 0.29 ± 0.03 mg m^{-3} was distributed to 50 meters with a chlorophyll maximum at 100 meters having 0.55 mg chl m^{-3} (Figure 2.4). A full suite of bio-optical measurements were made at this station.

A second opportunistic station (Station CWZ) was made at 58° 9'S 62° 8'W during transect south to Cape Sherriff at the beginning of Leg II. The temperature profile was more sharp than that found for Station BWZ, however decreasing temperatures began at 37 meters and the temperature minimum occurred at 158 meters with -0.28°C with a salinity of 34.02 $^{o}/_{oo}$ (e.g., also Water Zone I). Chlorophyll concentrations were uniformly distributed with 0.28 ± 0.02 mg chl m^{-3} for the first 50 meters, with no chlorophyll maximum observed.

Continuous monitoring of phytoplankton photophysiology using FRRF connected to the ship's continuous flow seawater system was also done in coastal and shelf regions of the South Shetland and Elephant Islands during the Seal Survey, in addition to that done during the southern excursion through the Gerlache Strait and back to Punta Arenas (Figure 2.2). For the homeward transect, hourly sampling for chlorophyll and high pressure liquid chromatography were obtained from the ship's continuous seawater flow system to 59°S (Figure 2.3A). The highest surface chlorophyll concentrations were measured in the Gerlache Strait (between Anvers Island and the LeMaire Passage) with chlorophyll concentrations reaching 21 mg m^{-3}, while the lowest values were found just south of the Polar Front with surface concentrations ranging 0.1-0.2 mg m^{-3}.

FRRF data may be interpreted as one indicator of phytoplankton growth rate potential by measuring variable-to-maximal fluorescence (Fv/Fm; Kolber and Falkowski, 1993; Kolber, *et al.*, 1994; Falkowski and Kolber, 1995). Our data from the continuous flow seawater system indicated that Fv/Fm had diel variability as directly related to incident solar radiation (Figure 3.3B), as has been reported (Vassiliev *et al.*, 1994). Although incident photosynthetically active radiation (PAR) accounted for much of this variability, Fv/Fm was secondarily influenced by the Water Zone from where the sample was taken. The Seal Survey mostly occupied shelf and shelf-break waters around King George and Elephant Islands (Figure 2.2), and the most variability in Fv/Fm in relation to PAR for these samples (Figure 2.3B) was found here. Similar large variability in Fv/Fm was found in the Bransfield, Gerlache and Bismark Straits which had amongst the highest near-surface chlorophyll concentrations measured during Leg I (>20 mg m^{-3}, Figure 2.3A). In contrast, extremely low chlorophyll containing waters of the ACC (Figures 2.2 & 2.3) demonstrated very little variability of Fv/Fm in relation to PAR. "Coastal" waters during the transect back to Punta Arenas (Figure 2.3B) represented transitional waters (probably Water Zones II and III) encountered between continental shelf and deep pelagic waters (Figure 2.2), and had intermediate concentrations of chlorophyll. The relationship between Fv/Fm and PAR similarly showed a transition between characteristics of high biomass and very low biomass containing waters. The range of values at low PAR for the Straits and coastal waters ranged 0.4 to 0.6, and compares with an upward value of 0.65 for actively growing cells in culture; for ACC and Polar Front waters, Fv/Fm ranged 0.1 to 0.3 at low PAR and compares with those of natural populations having iron limitation (Kolber *et al.*, 1994).

Further comparison between the response of Fv/Fm to PAR for phytoplankton communities in contrasting Water Zones is shown in Figure 2.4. Water column profiles of chlorophyll concentration, temperature, PAR, and Fv/Fm for Water Zones IV (Station A13-13; Figures 2.4A & C) and I (BWZ; Figures 2.4B & D) demonstrate these differences (see Figure 2.2 for locations). Station A13-13 was relatively rich in phytoplankton with >1.0 mg chl m^{-3} near the surface, and decreasing concentrations with depth that followed the pattern of temperature to indicate non-uniform mixing in the upper water column (for practical purposes, e.g. Mitchell and Holm-Hansen, 1991, defining an upper mixed layer, UML, as a change in density > 0.05 kg m^{-3} within 5 meters would indicate that this station did not have one; Figure 2.4A). In contrast, Station BWZ had an UML to 56 meters, but relatively low phytoplankton biomass until the beginning of the thermocline (Figure 2.4B). Both stations had approximately the same PAR at 5 meters (250 ΠEins m^{-2} s^{-1}), thus their Fv/Fm can be compared in this respect. For both stations, the Fv/Fm at 100 meters was approximately the same, whereas at the near surface the ratio was considerably higher for Station A13-13 (Figure 2.4C) than for Station BWZ (Figure 2.4D).

To this extent, it has been hypothesized that Water Zone I communities are limited by iron availability (Helbling *et al.*, 1991; Holm-Hansen *et al.*, 1994; Holm-Hansen *et al.*, 2002), and our Fv/Fm data are consistent with those from other high nutrient low chlorophyll waters where iron limited phytoplankton communities have values of ~0.3 (Kolber *et al.*, 1994). Our results from FRRF measurements suggest that the short-term physiological response of phytoplankton to PAR is measurably different for communities in Water Zone I than for other communities located in richer waters near the Antarctic Peninsula, and is consistent with previous results (e.g., Holm-Hansen *et al.*, 2000) that these same communities differ greatly in their non-photochemical quenching of fluorescence relative to chlorophyll concentration relative to PAR.

2.3.3 Unusual chlorophyll concentrations in Water Zone I: The horizontal and vertical distributions of chlorophyll were noticeably different during Leg I of the AMLR 2001/02 survey as compared to previous seasons. Satellite images of the horizontal distribution of chlorophyll show that during January, chlorophyll concentrations >1 mg m^{-3} lay extensively beyond the contours defining the 2,000-meter bottom depth north of the South Shetland Islands. In comparison, images from January 2001 (see Hewes *et al.*, 2001), and January 2000 (see Hewes *et al.*, 2000), show chlorophyll distributed near the South Shetland Islands at <2,000 meter bottom, and distributed with respect to the bottom topography. Although the AMLR survey has only extensively surveyed the waters north of Livingston Island since 1996/97, some comparisons can be made (Table 2.1). In general, waters lying well beyond the shelf break region (depths >2,000m) north of the South Shetland Islands have historically been classified as Water Zone I (see Physical Oceanography sections from AMLR Field Season Reports 1996/97 through 2000/01). For waters in the northwest sector of the West Area (61.5-62.0°S X 61.5-62.0°W), 5-meter chlorophyll measured during Leg I was 0.09± 0.03 mg m^{-3} (1996/97 – 2000/01, not done in 1999/00). In comparison, the same area measured 0.86 ± 0.21 during 2001/02. The 5-meter water temperature in this section was also colder than in previous years. During Leg II, water temperatures warmed up to almost the average for preceding years (Table 2.1). However, chlorophyll concentrations *diminished* to levels slightly above those from the preceding years, and are in contrast to a trend that phytoplankton biomass remains the same or slightly increases during Leg II. The same general conclusions can be made with regard to temperature and phytoplankton biomass in the northeast sector of the West Area (61.0S-61.5°S X 60.5S-61.0°W; Table 2.1), that cooler water temperatures and higher than average phytoplankton persisted during Leg I, and approached normal levels during the course of Leg II. This is born out by the SeaWiFS chlorophyll images for the general Drakes Passage/Scotia Sea region for January through March monthly composites (Figure 2.5).

That chlorophyll decreased during Leg II could be due to the much later time of the season that samples were obtained as compared to previous years. Evidence for this is found with the monthly composite image of chlorophyll distribution during February (Figure 2.5). A bloom developed south of King George Island in the Bransfield Strait while we were in transit between

Legs I and II as well as during the Near Shore Survey. This bloom persisted for the weeks ending February 9 and February 17 as indicated by 8-day composites of chlorophyll distributions (Figure 2.6). Of further note was the development and persistence of an eddy-like bloom just north of the Elephant Island Area along the Shackleton Fracture Zone. Eight-day composites (Figure 2.6) show the beginning of bloom formation around the week of January 16, maximizing its extent through the month of February, and decaying sometime in March (clouds obstructed further observation after March 13). The central portions of this bloom provided some of the highest concentrations of chlorophyll (red spots in the image for March 13) for the entire northern Peninsular region (also see Figure 2.5).

Regardless of the fact that during Leg I surface water temperatures were below normal for the AMLR Survey Areas mentioned above (Table 2.1), water column profiles indicated that Water Zone I was in evidence (Figure 2.7A). For Station 19-09 (located in the northwestern section of the West Area, Table 2.1), temperature/salinity plots classify this station as Water Zone I, with temperature minimums occurring at 50-100 meter depth. For Station 15-05 (located in the northeastern section of the West Area, Table 2.1), temperature/salinity plots classify this station as Water Zone I during Leg II, but borderline Water Zones I-II during Leg I. Holm-Hansen *et al.* (1997) distinguished two classes of Water Zone I as based on both nutrient concentration and the horizontal chlorophyll distribution. Water Zone IA waters were of very low chlorophyll concentrations (<<0.4 mg m^{-3}) distributed in the UML, with a small chlorophyll maximum that lay just below the beginning of the thermocline (see Figure 2.4B). Water Zone IB waters resembled Water Zone IA waters in the physical sense by having a distinct temperature minimum, but chlorophyll concentrations were two-to-three times higher (0.3-0.6 mg m^{-3}) in the UML and no chlorophyll maximum present. For both Legs, few stations met the biological criteria of being Water Zones 1A for the 2001/02 field season survey. Holm-Hansen *et al.* (1997) suggested that the higher biomass in Water Zone IB waters could be the result of a lateral advection from coastal surface waters, since these contained similar macro nutrient concentrations, shoaled on top of the Winter Water layer, which provided the temperature minimum characteristics of Water Zone I. Yet, even with satellite images of the surface chlorophyll distributions for the general region encompassing the AMLR survey region (Figures 2.5 & 2.6), it is difficult to assess what mesoscale processes were dominating the physical environment to provide conditions of elevated phytoplankton biomass in such normally oligotrophic pelagic waters. Although Station 15-05 developed into a Water Zone IA - like situation with regard to the physical structure and chlorophyll concentration of the water column during Leg II (Figure 2.7B), chlorophyll concentrations remained well above those that have been considered normal for Water Zone IB waters.

2.4 Disposition of the Data: All chlorophyll and CTD-interfaced sensor data obtained during these cruises have been archived with AERD, Southwest Fisheries Science Center. Data from all other measurements listed in 2.2.2 will be processed by Dr. B.G. Mitchell under his NASA SIMBIOS project.

2.5 Problems and Suggestions: It should be noted that the phytoplankton component of the AMLR program has not obtained funds for the calibration, repair, or replacement of field equipment (both laboratory equipment and *in situ* sensors) used in these annual surveys. Many of our instruments devoted to this program (originally obtained from other funding agencies) for the past 13 years began to fail the past few years, and the situation has become critical. Additional NOAA funding should be made available to maintain and/or replace such instruments, since the scope and quality of our data for future AMLR field years will be compromised.

2.6 Acknowledgements: We want to express our gratitude and appreciation to the entire complement of the R/V *Yuzhmorgeologiya* for their generous and valuable help during the entire cruise. They not only aided immeasurably in our ability to obtain the desired oceanographic data, but they also made the cruise most enjoyable and rewarding in many ways. We also thank all other AMLR personnel for help and support which was essential to the success of our program. This report has been funded in part to O. Holm-Hansen from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, under grant NA17RJ1231, and by a NASA SIMBIOS Project Award to B. Greg Mitchell, NAS5-01002. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its sub-agencies.

2.7 References:

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Table 2.1. Comparison of AMLR 2001/02 chlorophyll concentrations and temperature with those of previous years for two regions in the West Area. Leg I chlorophyll was much higher and surface water temperature much cooler than the average from previous surveys. Leg II also deviated from "normal", but was not as extreme as Leg I. Also see Figure 2.7.

Area	Year(s)		Leg I				Leg II			
			N =	Temp., °C	5 m Chl, mg m^{-3}	Integr. Chl, mg m^{-2}	N =	Temp., °C	5 m Chl, mg m^{-3}	Integr. Chl, mg m^{-2}
61.5 - 62.0 °S X 61.5 - 62.0 °W	1997 - 2001	average	11	2.09	0.09	14.73	8	2.45	0.18	14.94
		stdev		0.54	0.03	9.19		0.41	0.20	11.15
	2002	average	3	1.36	0.86	67.19	3	2.23	0.55	47.76
		stdev		0.28	0.21	17.05		0.32	0.30	22.98
61.0 - 61.5 °S X 60.5 - 61.0 °W	1997 - 2001	average	11	2.41	0.15	11.49	7	2.59	0.16	30.43
		stdev		0.47	0.16	11.61		0.71	0.28	15.81
	2002	average	3	1.28	0.59	43.90	4	2.38	0.38	33.17
		stdev		0.22	0.33	20.15		0.20	0.23	20.89

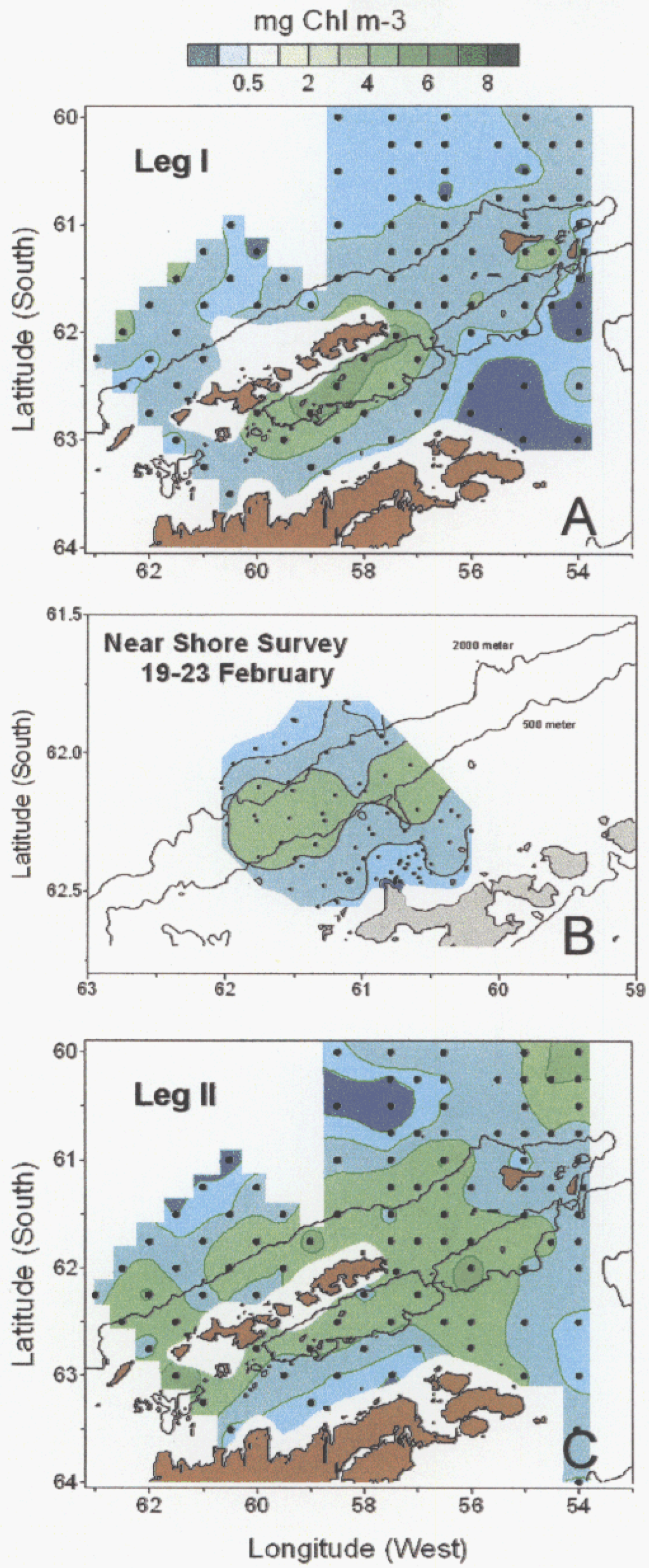


Figure 2.1. Distributions of near surface chlorophyll concentrations during (A) Leg I, (B) the near shore survey, and (C) Leg II. The 2000 meter bottom contour line is shown in A and B, while both 500 and 2000 meter bottom contour lines are shown in C. Filled circles represent locations that bottle samples were made. For A and C, 5 meter bottle data (10 meter if missing 5 meter) plotted. For the near shore survey, B, concentrations plotted were from the continuous flow seawater system (~7 meter depth) sampled every two hours.

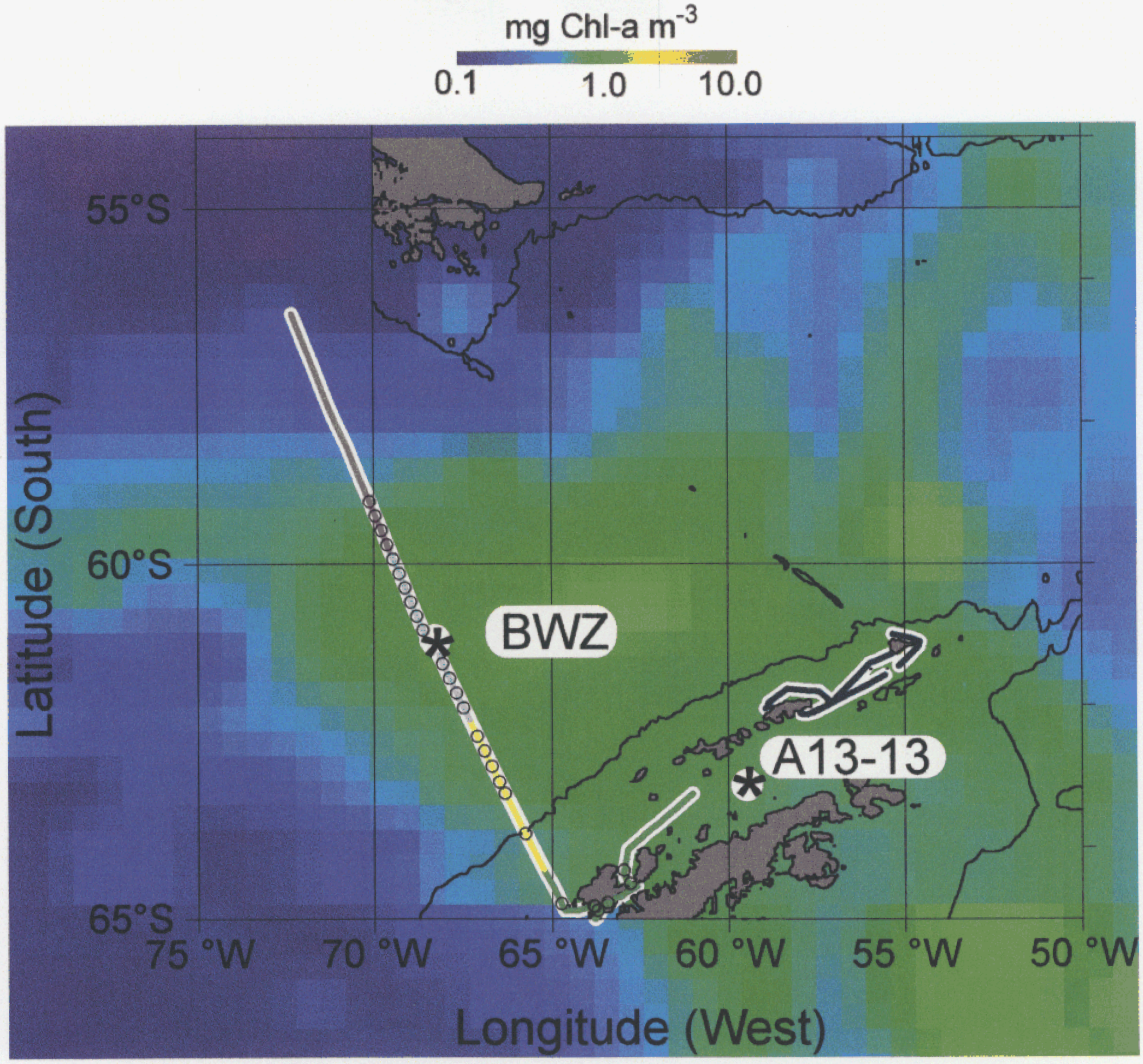


Figure 2.2. Cruise track of the underway sampling where FRRF was attached to the continuous flow seawater system overlaying chlorophyll distribution for monthly composite for February, 2002, as measured by SeaWiFS satellite (see text for details). Symbols are the locations where chlorophyll and HPLC samples were taken. Colors of the cruise track lines refer to areas described in Figures 3 and 4, corresponding with: Black, Seal Survey; Green, Straits; Yellow, Coastal; Light Blue, ACC; Violet, Polar Front. The 2,000 meter bottom contour drawn as the thin light black line. The locations of Stations A13-13 and BWZ are shown.

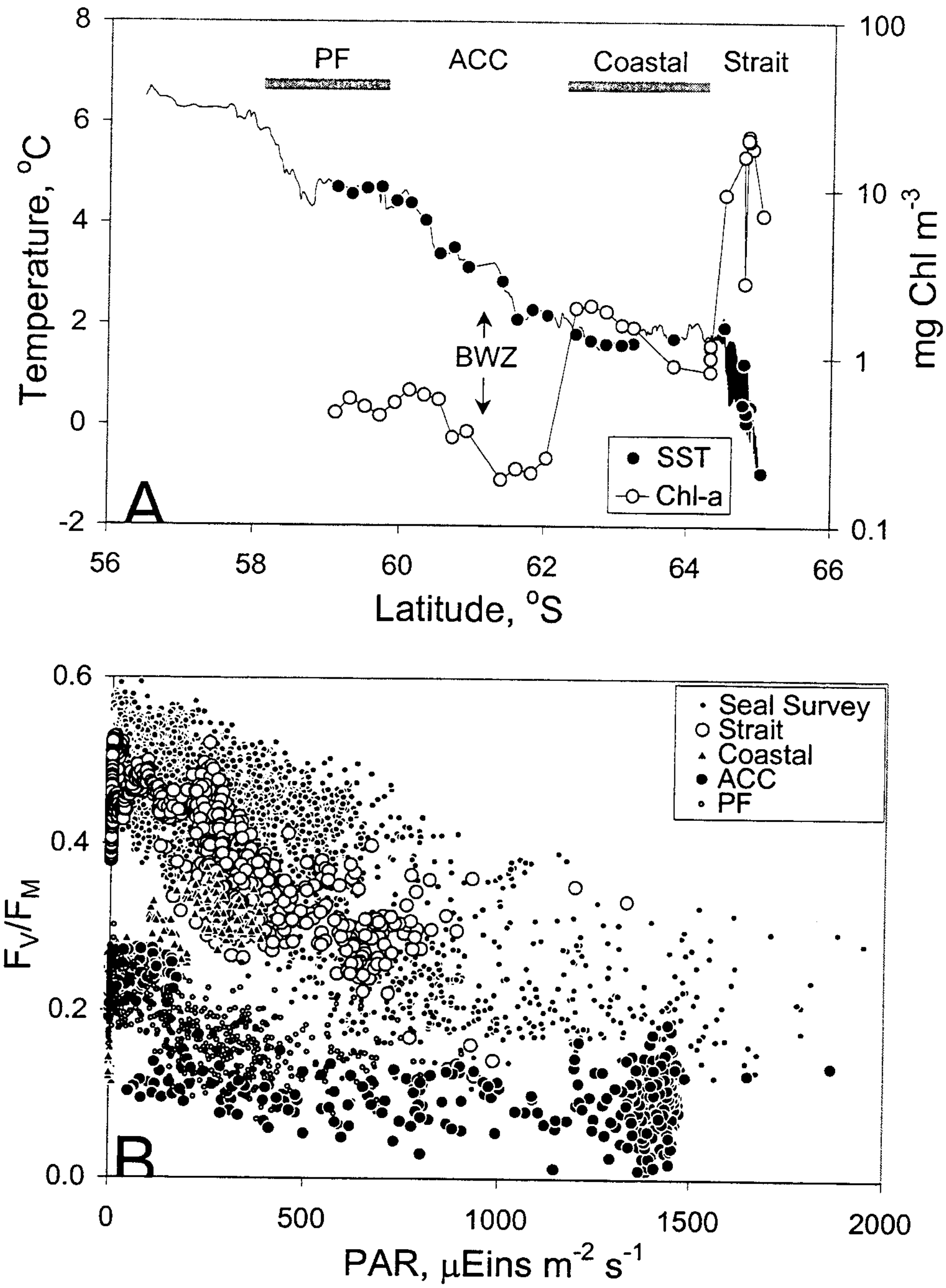


Figure 2.3. A) Chlorophyll concentration and temperature measured at locations shown in Figure 2 during the return to Punta Arenas at the end of Leg I. Four areas, Strait (Bransfield, Gerlache, and Bizmark Straits), Coastal, Antarctic Circumpolar Current (ACC), and Polar Front (PF) were based on chlorophyll concentration and temperature. B) Fv/Fm (measured by FRRF hooked up to the continuous flow seawater system) plotted against ambient PAR. The areas described in A are compared to those values measured during the Fur Seal Pup Survey.

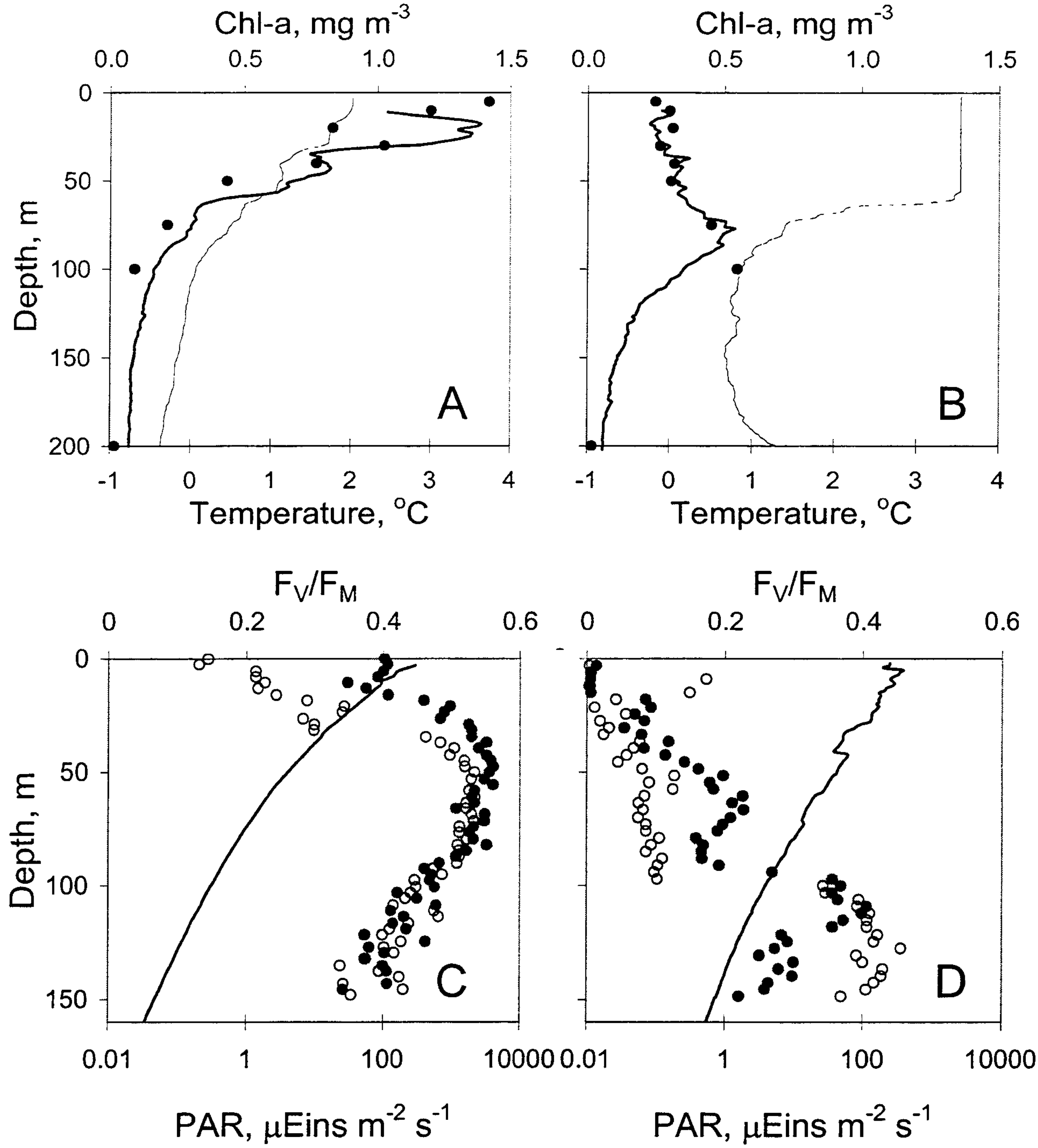


Figure 2.4. Comparison of vertical profiles for (A and B) temperature (thin lines), chlorophyll (filled circles) and chlorophyll estimated from in situ fluorescence and PAR (Holm-Hansen *et al.*, 2000; heavy lines), and (C and D) PAR (heavy lines) and Fv/Fm (measured in the dark, filled circles, and in the light, open circles) between Station A13-13 (Bransfield Strait, A and C) and Station BWZ (B and D).

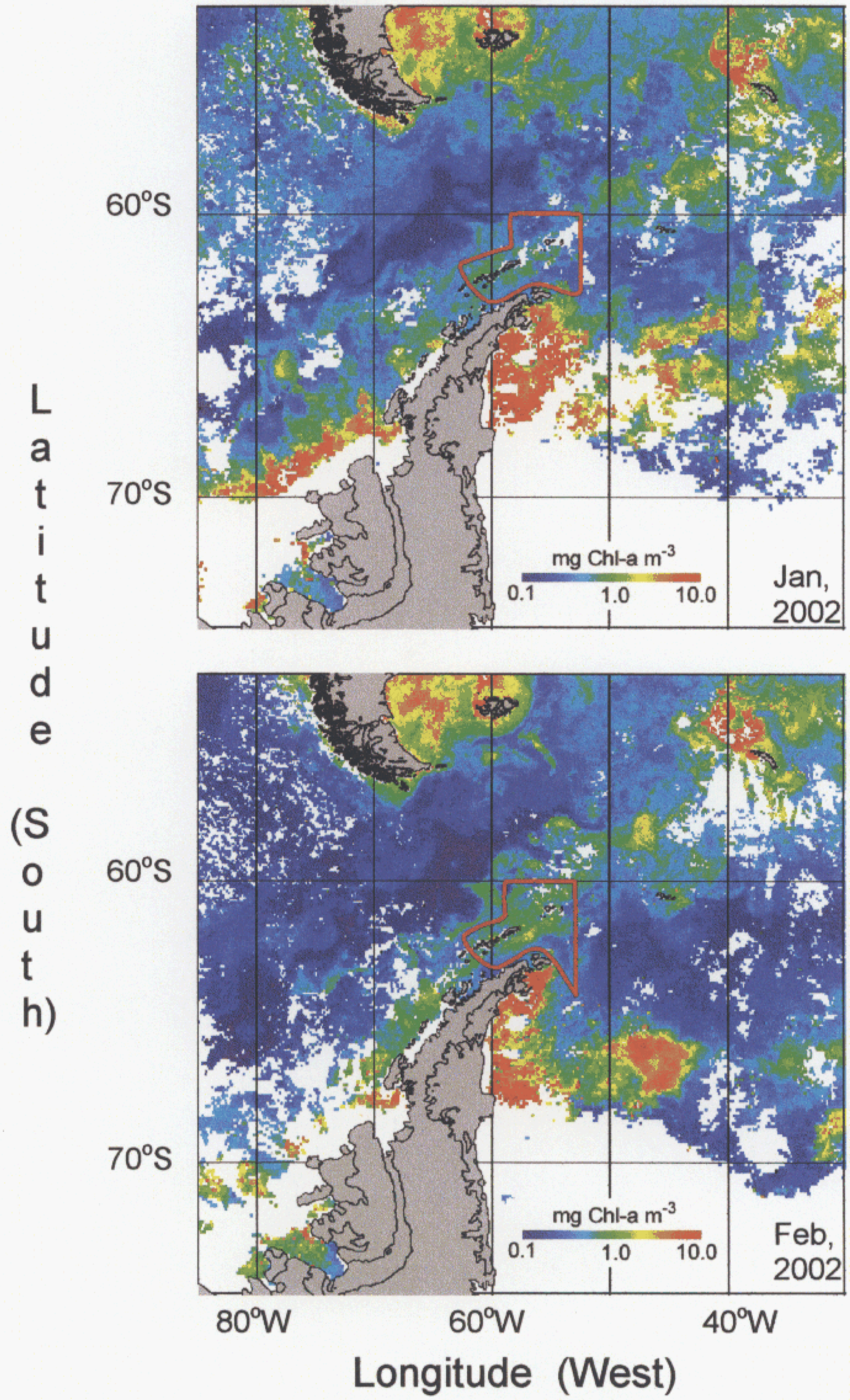


Figure 2.5. Monthly composites for SeaWiFS satellite derived chlorophyll distributions for January and February, 2002 in the regions surrounding the AMLR survey area (enclosed red areas) during Legs I and II. Note both (1) the strengthening of the low chlorophyll containing region (deep blue) between South America and the Antarctic Peninsula and (2) intensification of phytoplankton blooming (green and yellow) around the Shetland / Elephant Islands region and northeastward towards South Georgia. White areas represent persistent ice and cloud cover.

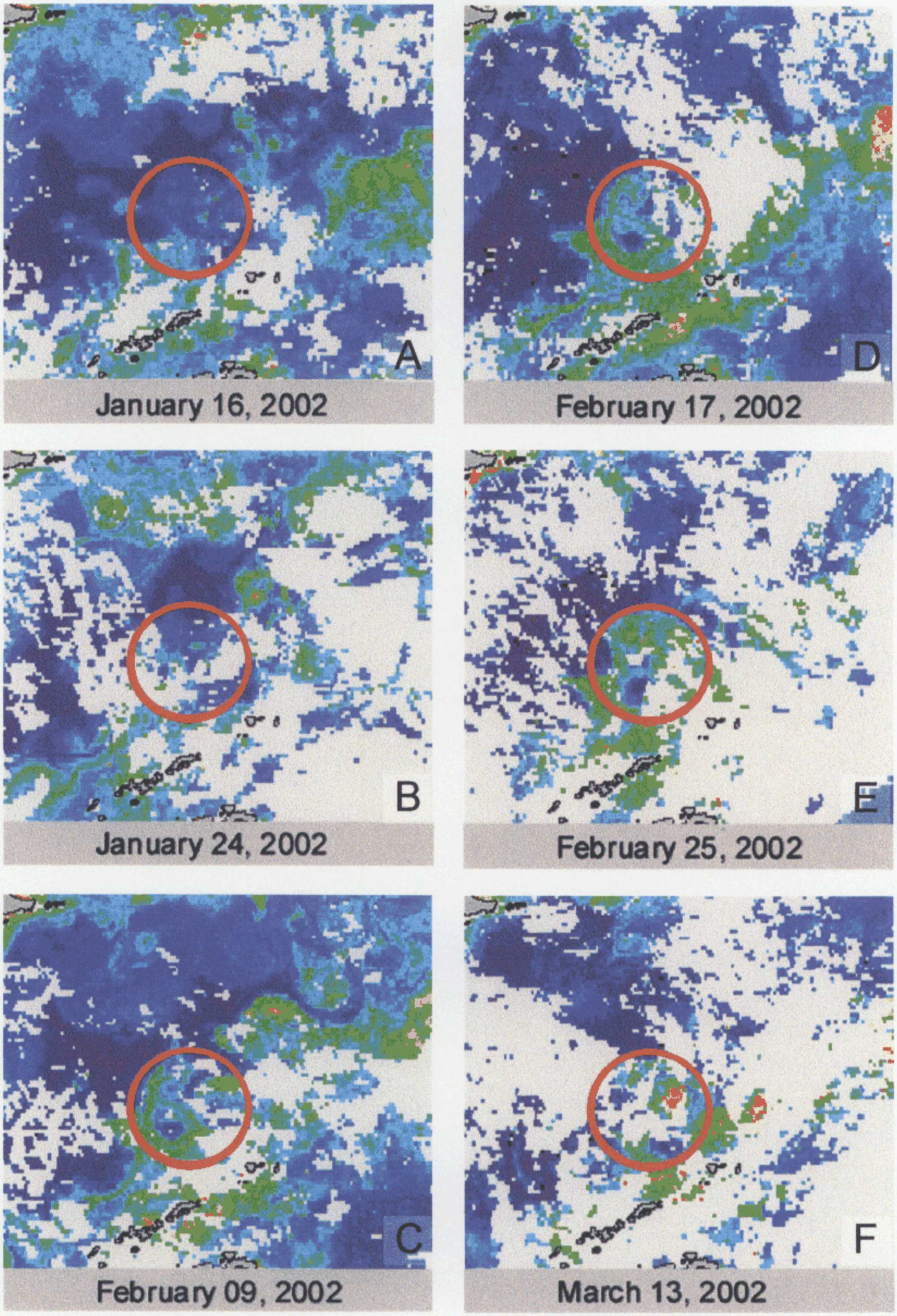


Figure 2.6. Eight-day composites of SeaWiFS satellite chlorophyll distributions showing development and persistence of an off-shelf phytoplankton bloom (red circle) during the AMLR 2001/02 field survey. Refer to Figure 5 for color scale and relative locations (red circle centered at approximately 59°S 58°W). Light grey represents cloud cover.

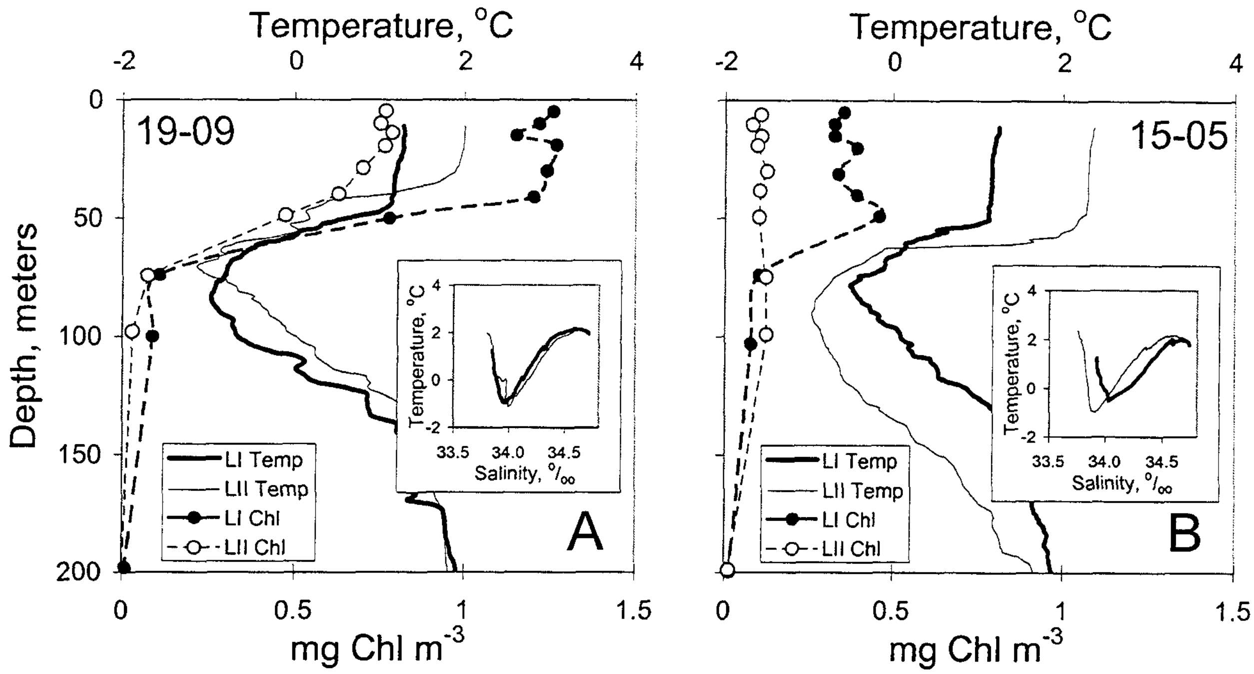


Figure 2.7. Vertical distributions of chlorophyll (circles) and temperature (solid lines) for stations 19-09 (A) and 15-05 (B) (northwest and northeast corners of the West Area, also see Table I) to compare Legs I (heavy lines) and II (light lines). Inserts show the relationship of temperature verses salinity. Water Zone I is characterized by a temperature minimum having a salinity <34.0 $^{o}/_{oo}$, for which all were except for Station 15-05 (B) Leg I which was Water Zone II. Typically Water Zone I may be characterized (e.g., Holm-Hansen *et al.*, 1997) as IA, having low chlorophyll concentrations (<0.2 mg m^{-3}) between the surface and thermocline and a chlorophyll maximum (<0.5 mg m^{-3}) just below the thermocline, or IB, having uniformly distributed chlorophyll (0.3-0.6 mg m^{-3}) to the thermocline. Station 15-05 during Leg II (B) was the only "typical" IA condition, with the others shown as having much higher concentrations of chlorophyll than usually considered for IB waters.

3. Bioacoustic survey; submitted by Jennifer H. Emery (Leg I & II), Roger P. Hewitt (Leg I), and David A. Demer (Leg II).

3.1 Objectives: The primary objectives of the bioacoustic survey during Legs I and II were to: (1) map the meso-scale dispersion of krill in the vicinity of the South Shetland Islands; (2) to estimate their biomass; (3) and to determine their association with predator foraging patterns, water mass boundaries, spatial patterns of primary productivity, and bathymetry.

3.2 Methods and Accomplishment: Acoustic data were collected using a multi-frequency echo sounder (Simrad EK500) configured with down-looking 38, 120, and 200 kilohertz (kHz) transducers mounted in the hull of the ship. System calibrations were conducted before and after the surveys using standard sphere techniques while the ship was at anchor south of Elephant Island near Endurance Glacier and in Admiralty Bay, King George Island. During the surveys, pulses were transmitted every 2 seconds at 1 kilowatt for 1 millisecond duration at 38kHz, 120kHz, and 200kHz. Geographic positions were logged every 60 seconds. Ethernet communications were maintained between the EK500 and two Windows 2000 workstations. Both Windows 2000 workstations were running SonarData EchoLog and EchoView software. One unit was used for primary system control, and data logging, processing and archiving while the other ran in parallel for back-up logging and archiving.

Acoustic surveys of the water surrounding the South Shetland Islands were conducted on Legs I and II. These surveys were divided into four areas (See Figure 2 in Introduction): (1) a 43,865km^2 area centered on Elephant Island (Elephant Island Area) was sampled with seven north-south transects; (2) a 38,524km^2 area along the north side of the southwestern portion of the South Shetland archipelago (West Area) was sampled with six transects oriented northwest-southeast and one oriented north-south; (3) a 24,479km^2 area in the western Bransfield Strait (South Area) was sampled with six transects oriented northwest-southeast; and (4) an 18,151 km^2 area north of Joinville Island (Joinville Island Area) was sampled with three transects oriented north-south.

A faulty high-voltage power supply was discovered during the first half of Survey A. A new power supply was installed and the EK500 echosounder was re-calibrated.

3.2.1 Krill Delineation Legs I and II (Survey D):

Krill densities were estimated using a three-frequency delineation method as opposed to the two-frequency method used in past research (Madureira *et al.*, 1993). This method reduced the inclusion of other euphausiid species and myctophid fish in the biomass estimate. A ΔMVBS (mean volume backscattering strength) window of 4 to 16dB was set as the acceptable difference between the 120kHz and 38kHz data for labeling acoustic target as krill. However, this preset criteria allowed the inclusion of a small amount of myctophids in the final krill density estimate. Therefore a second ΔMVBS window of –4 to 2dB was established as the acceptable difference between the 120kHz and 200kHz transducer data in which backscattering values would be attributed to krill. The combined application of these two windows (three-frequency method) eliminated all acoustic targets not classified as Antarctic krill (Figure 3.1). The window ranges were selected based on models of krill backscattering strength at each frequency (Demer, in press).

3.2.2 Abundance Estimation and Map Generation:

Backscattering values were averaged over 5m by 100s bins. Time varied noise was subtracted from the echogram and the ΔMVBS window was applied. The remaining volume backscatter classified as krill (S_v) was integrated over depth (500m) and averaged over 1852m (1 nautical mile) distance intervals. These data were processed using SonarData Echoview software.

Integrated krill nautical area scattering coefficient (NASC) (Maclennan and Fernandes, 2000) was converted to estimates of krill biomass density (ρ) by applying a factor equal to the quotient of the weight of an individual krill and its backscattering cross-sectional area, both expressed as a function of body length and summed over the sampled length frequency distribution for each survey (Hewitt and Demer, 1993):

$$\rho = 0.249 \sum_{i=1}^{n} f_i (l_i)^{-0.16} \text{NASC} \quad (\text{g/m}^2)$$

Where

$$\text{NASC} = 4\pi (1852)^2 \int_0^{500} S_v \qquad (\text{m}^2/\text{n.mi.}^2)$$

And f_i = the relative frequency of krill of standard length l_i.

For each area in each survey, mean biomass density attributed to krill and its variance were calculated by assuming that the mean density along a single transect was an independent estimate of the mean density in the area (Jolly and Hampton, 1990).

3.3 Tentative Conclusions: During Survey D (Leg II), the highest concentration of krill was mapped north of Livingston Island along the shelf break (Figure 3.2). High concentrations of krill were also found northeast of King George Island/west of Elephant Island, north of Clarence Island, and in the Bransfield Strait west of Deception Island and northwest of the Antarctic Peninsula. Krill scattering layers were typically found between 50m and 250m. Krill density estimates are listed by areas and transect in Table 3.2.

Mean krill biomass densities within the ten years of the AMLR surveys were highest in 1996/97 and lowest in 2001/02 (Table 3.1). The historical U.S.-AMLR acoustic data collected in the Elephant Island Area has recently been re-processed with the three-frequency method (Hewitt *et al.,* in press). A model of the variability of acoustic estimates of krill in the Elephant Island Area predicts increasing krill density in 2002/03 (Figure 3.3). This approach is considered more conservative compared to application used in past research and reduces the possibility of over-estimating krill biomass, but may also exclude some less aggregated krill swarms.

Survey A (Leg I) krill densities are presented as a range (Tables 3.1 and 3.2). The two values represent data processed with settings obtained during the initial calibration with the faulty power supply versus data processed with settings obtained during the calibration following the installation of the new power supply. Because of the compromised integrity of this data, no distribution map is presented for Survey A.

3.4 Disposition of Data: All integrated acoustic data will be made available to other U.S. AMLR investigators in ASCII format files. The analyzed echo-integration data consume approximately 10 Mbytes. The data are available from Jennifer H. Emery, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037; phone/fax – (858) 546-5609/546-5608; e-mail: Jennifer.Emery@noaa.gov.

3.5 References:

Demer, D.A. In press. An estimate of error for the CCAMLR 2000 estimate of krill biomass. *Deep Sea Research II, Special issue.*

Hewitt, R.P., Demer, D.A., and Emery, J.H. In press. An eight year cycle in krill biomass density inferred from acoustic surveys conducted in the vicinity of the South Shetland Islands during the austral summers of 1991/92 through 2001/02. *ICES Journal of Marine Science.*

Hewitt, R.P. and D.A. Demer. 1993. Dispersion and abundance of Antarctic krill in the vicinity of Elephant Island in the 1992 austral summer. *Maine Ecology Progress Series* 99: 29-39.

Jolly, G.M. and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. *Canadian Journal of Fisheries Aquatic Science* 47: 1282-1291.

Maclennan, H. and Fernandes, P. Definitions, units and symbols in fisheries acoustics. Draft 03/04/00. Contr FAST Working Group Meeting, Haarlem, April 2000, 6p.

Maduriera, L.S.P., Ward, P., and Atkinson, A. 1993. Differences in backscattering strength determined at 120 and 38 kHz for three species of Antarctic macroplankton. *Marine Ecology Progress Series* 99: 17-24.

Table 3.1. Mean krill biomass density for surveys conducted from 1992 to 2002. Coefficients of variation (CV) are calculated by the methods described in Jolly and Hampton, 1990, and describe measurement imprecision due to the survey design. 1993 estimates were omitted due to system calibration uncertainties; only one survey was conducted in 1996/97; 1998/99 South Area values are not available due to lack of data. See Figure 2 in the Introduction Section for description of each survey area.

Survey	Area	Mean Density (g/m^2)	Area (km^2)	Biomass (10^3 tons)	CV %
1992 A (late January)	Elephant Island	61.20	36,271	2,220	15.8
D (early March)	Elephant Island	29.63	36,271	1,075	9.2
1994 A (late January)	Elephant Island	9.63	41,673	401	10.7
D (early March)	Elephant Island	7.74	41,673	323	22.2
1995 A (late January)	Elephant Island	27.84	41,673	1,160	12.0
D (early March)	Elephant Island	35.52	41,673	1,480	24.2
1996 A (late January)	Elephant Island	80.82	41,673	3,368	11.4
D (early March)	Elephant Island	70.10	41,673	2,921	22.7
1997 A (late January)	Elephant Island	100.47	41,673	4,187	21.8
1998 A (late January)	Elephant Island	82.26	41,673	3,428	13.6
	West	78.88	34,149	2,694	9.9
	South	40.99	8,102	332	16.3
D (late February)	Elephant Island	47.11	41,673	1,963	14.7
	West	73.32	34,149	2,504	16.6
	South	47.93	8,102	388	12.2
1999 A (late January)	Elephant Island	23.72	41,673	988	20.3
	West	27.13	34,149	927	28.7
	South	19.68	8,102	159	9.4
D (late February)	Elephant Island	15.37	41,673	641	26.0
	West	11.85	34,149	405	30.0
	South	N/A	8,102	N/A	N/A
2000 D (late February)	West	37.54*	34,149	1,282	14.1
	Elephant Island	36.19*	41,673	1,508	21.1
	South	22.75*	8,102	184	29.2
2001 A (late January)	West	16.98†	34,149	580	22.5
	Elephant Island	15.57†	41,673	649	13.9
	South	12.64†	8,102	102	22.2
D (late February)	West	16.26†	34,149	555	33.9
	Elephant Island	12.77†	41,673	532	11.6
	South	9.59†	8,102	78	40.1
2002 A (late January)	West	0.57-5.54‡‡	38,524	22-213	52.6, 44.7
	Elephant Island	1.71-4.07‡‡	43,865	75-178	58.3, 19.3
	South	1.27-1.80‡‡	24,479	31-44	51.4, 40.6
	Joinville Island	1.05‡‡	18,151	19	9.2
D (late February)	West	0.92‡‡	38,524	35	62.1
	Elephant Island	0.84‡‡	43,865	37	18.9
	South	0.80‡‡	24,479	20	27.1
	Joinville Island	0.51‡‡	18,151	9	73.3

*Data values are based on the two-frequency krill delineation method.

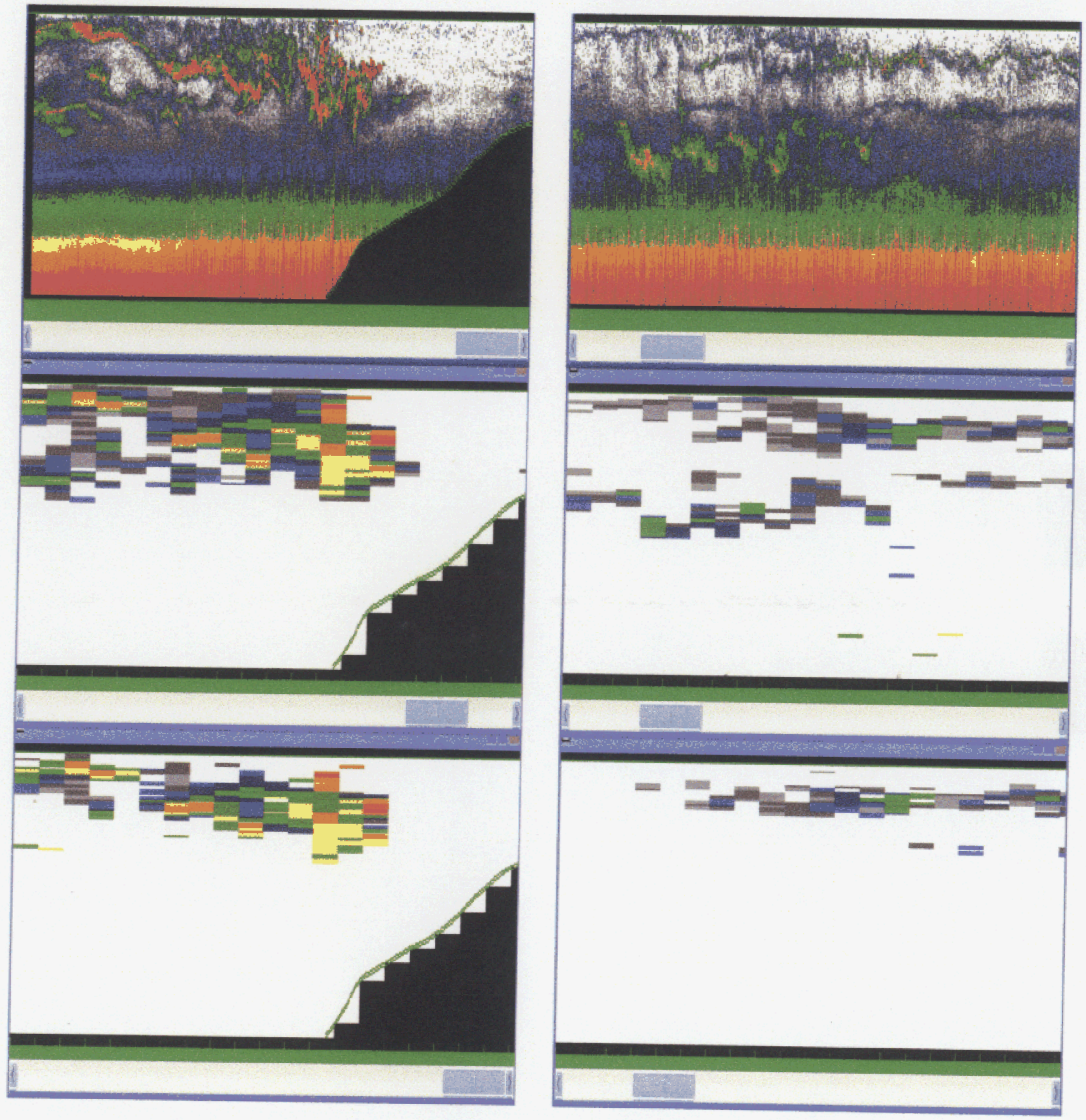
†Data values are based on the three-frequency krill delineation method (2-14dB difference between 120 and 38kHz and 0-5dB difference between 200 and 120kHz).

‡‡ Data values are based on the three-frequency krill delineation method (4-16dB difference between 120 and 38kHz and –4-2dB difference between 200 and 120kHz).

All other density measurements within this table are based on total volume backscatter.

Table 3.2. Krill density estimates by area and transect for Surveys A and D, Legs I and II

Elephant Island Area			
		Survey A	Survey D
	n	krill density	krill density
Transect 1	105	0.19-2.16	0.38
Transect 2	92	0.07-3.37	0.42
Transect 3	117	0.23-5.54	1.29
Transect 4	97	0.25-5.79	0.58
Transect 5	138	6.52-6.79	1.00
Transect 6	90	1.08-1.08	0.59
Transect 7	101	3.03-3.08	1.43
West Area			
		Survey A	Survey D
	n	krill density	krill density
Transect 1	42	1.09-15.72	0.14
Transect 2	45	2.49-18.29	0.17
Transect 3	41	1.20-4.86	0.08
Transect 4	63	0.06-0.81	3.87
Transect 5	64	0.00-2.12	1.36
Transect 6	62	0.29-4.66	0.15
Transect 7	89	0.04-0.63	0.16
South Area			
		Survey A	Survey D
	n	krill density	krill density
Transect 1	56	0.61	1.01
Transect 2	43	1.12	0.00
Transect 3	41	0.34	0.80
Transect 4	22	7.38	0.02
Transect 5	43	1.41	1.16
Transect 6	40	0.09-3.30	1.39
Joinville Island Area			
		Survey A	Survey D
	n	krill density	krill density
Transect 1	61	1.07	1.28
Transect 2	59	1.22	0.12
Transect 3	48	0.82	0.00



Original

Filtered for
4dB < ($Sv_{120} - Sv_{38}$) < 16dB

Filtered for
< (Sv_{200} – -4dB Sv_{120}) < 2dB

Figure 3.1. Two examples of 120kHz echograms representing the three-frequency method of krill delineation.

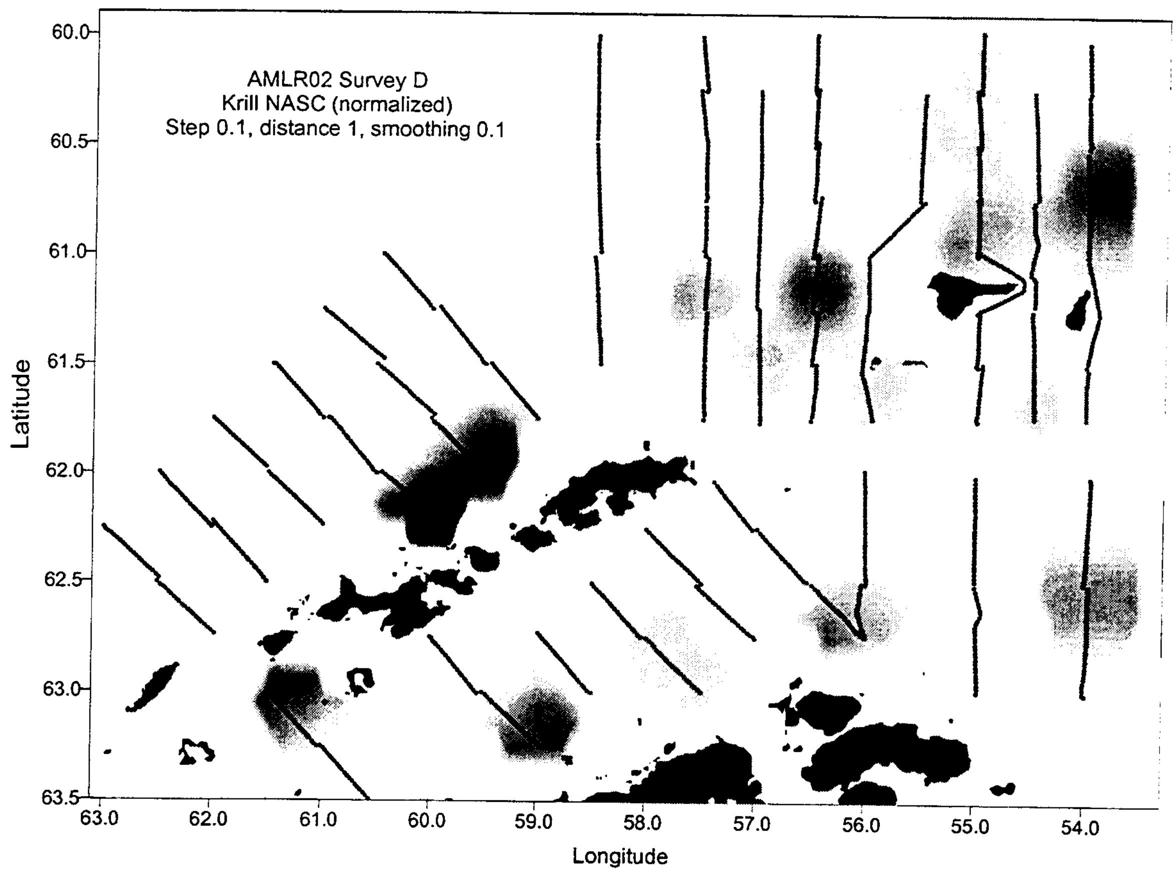


Figure 3.2. Distribution of sample-weighted krill NASC ($m^2/n.mi.^2$) for Survey D collected at 120kHz. Parameters refer to 'track and fields' software settings used for smoothing. Dark areas are indicative of high concentrations of krill.

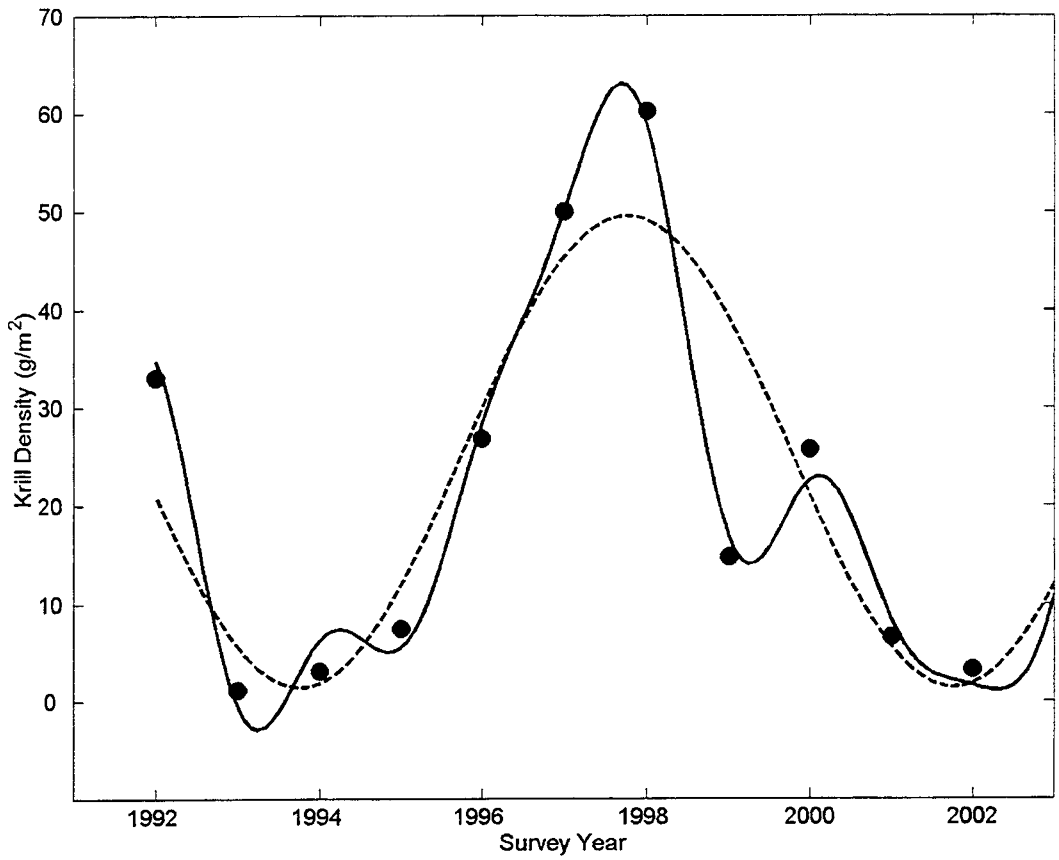


Figure 3.3. Time series of krill biomass density in the Elephant Island Area from January 1991/92 to 2001/2002 using a three-frequency method to delineate volume backscattering from krill (Hewitt *et al.*, in press). The solid line represents a truncated Fourier series fit to the data and indicating dominant cycles at 3 and 8 years. The dark line indicates an 8-year cycle fit to the time series.

4. Net sampling: Krill and zooplankton; submitted by Valerie Loeb (Legs I & II), Emma Bredesen (Legs I & II), Michael Force (Legs I & II), Nancy Gong (Legs I & II), Adam Jenkins (Legs I & II), Lorena Linacre (Legs I & II), Shelly Peters (Legs I & II), and Rob Rowley (Legs I & II).

4.1 Objectives: Here we provide information on the demographic structure of Antarctic krill (*Euphausia superba*) and abundance and distribution of salps and other zooplankton taxa in the vicinity of Elephant, King George and Livingston Islands. Essential krill demographic information includes length, sex ratio, maturity stage composition and reproductive condition. Information useful for determining the relationships between krill and zooplankton distribution patterns and ambient environmental conditions was derived from net samples taken at established CTD/phytoplankton stations. The salp, *Salpa thompsoni*, and copepod species receive special attention because their interannual abundance variations may reveal underlying hydrographic processes influencing the Antarctic Peninsula ecosystem. Results are compared to those from previous AMLR surveys to assess between-year differences in krill demography and zooplankton composition and abundance over the 1992-2002 period. Additional historical data from the Elephant Island Area are used to examine copepod species abundance and abundance relations between 1981 and present.

4.2 Accomplishments:

4.2.1 Large-Area Survey Samples:

Krill and zooplankton were obtained from a 6' Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505μm mesh plankton net. Flow volumes were measured using a calibrated General Oceanics flow meter mounted on the frame in front of the net. All tows were fished obliquely from a depth of 170m or to ca. 10m above bottom in shallower waters. Real-time tow depths were derived from a depth recorder mounted on the trawl bridle. Tow speeds were ca. 2kts. Samples were collected at Large-Area survey stations during both cruise legs. Four regionally distinct groups of stations are considered (See Figure 2 in Introduction; Figures 4.1A & B). Elephant Island Area stations represent the historically sampled area used for long-term analyses of the Antarctic Peninsula marine ecosystem. West Area stations, north of King George and Livingston Islands, form a database with which to examine the abundance and length composition of krill stocks available to predator populations at Cape Shirreff and to the krill fishery that operates in this area during summer months. Within Bransfield Strait the South Area stations are used to monitor krill supplies available to predator populations in Admiralty Bay, King George Island, while the Joinville Island Area stations, to the east, are sampled to determine whether significant aggregations of juvenile krill occur there in association with Weddell Sea influence.

4.2.2 Shipboard Analyses:

All samples were processed on board. Krill demographic analyses were made using fresh or freshly frozen specimens. Other zooplankton analyses were made using fresh material within two hours of sample collection. Abundance estimates of krill, salps, and other taxa are expressed

as numbers $1{,}000m^{-3}$ water filtered. Abundance information is presented for the Elephant Island, West, South and Joinville Island Areas, and for the total survey area.
(A) Krill. Krill were removed and counted prior to other sample processing. All krill from samples containing <150 individuals were analyzed. For larger samples, generally 100-200 individuals were measured, sexed, and staged. Measurements were made of total length (mm); stages were based on the classification scheme of Makarov and Denys (1981).

(B) Salps. All salps were removed from samples of 2L or less and enumerated. For larger catches, the numbers of salps in 1 to 2L subsamples were used to estimate abundance. For samples with ≤100 individuals, the two life stages (aggregate/sexual and solitary/asexual) were enumerated and internal body length (Foxton, 1966) was measured to the nearest millimeter. Representative subsamples of ≥100 individuals were analyzed in the same manner for larger catches.

(C) Fish. All adult myctophids were removed, identified, measured to the nearest millimeter Standard Length, and frozen.

(D) Zooplankton. After krill, salps, and adult fish were removed the remaining zooplankton fraction was analyzed. All of the larger organisms (e.g., other postlarval euphausiids, amphipods, pteropods, polychaetes) were sorted, identified to species if possible, and enumerated. Following this the samples were aliquoted and smaller zooplankton (e.g., copepods, chaetognaths, euphausiid larvae) in three or four subsamples were enumerated and identified to species if possible using dissecting microscopes. After analysis the zooplankton samples (without salps and adult fish) were preserved in 10% buffered formalin for long term storage.

With the expanded survey grid this year came the introduction of higher latitude zooplankton taxa that previously had not been encountered. This was especially true in the Joinville Island Area, influenced by Weddell Sea shelf water, and South Area adjacent to, and influenced by, outflow from Gerlache Strait. Implementation of a more protective cod-end also increased the numbers of previously unidentifiable delicate taxa. Notable additions to the faunal assemblage were abundant larval and juvenile fishes (e.g., *Trematomus newnesi, T. scotti, T. lepidorhinus, Prionodraco evansii, Parachaenichthys charcoti*), tentatively identified jellies (e.g., *Zanclonia weldoni, Modeeria rotunda, Chromatonema rubra*), pteropods (*Clio pyramidata sulcata, C.p. antarctica* and *C.p. mertensi*), unidentified decapod larvae and "ice krill", *Euphausia crystallorophorias.*

While identification tools at hand permitted us to name many of the new taxa, large concentrations of euphausiid larvae (primarily late calyptopis and early furcilia), particularly in the Joinville Island Area during Leg I, created concerns. These *Euphausia* spp. larvae potentially were *E. crystallorophorias*, the dominant euphausiid in higher latitude pack-ice zones. Antarctic krill and "ice krill" have similar spawning periods (December to February). During prior AMLR surveys, postlarval *E. crystallorophorias* were rarely collected and larvae never identified. Because *E. superba* and *E. crystallorophorias* larvae are similar in size and appearance there is no assurance that they were adequately separated during Survey A (Leg I) sample analyses. This is a serious matter as projections about krill year-class success are in part based on their larval abundance during January-March surveys. An additional sample from known spawning grounds of *E. crystallorophias* was therefore required to establish larval identification aids for these species. This sample, collected in Bismarck Strait (Antarctic Peninsula) after Survey A, allowed us to focus upon species identifications of freshly caught euphausiid larvae based on pigmentation and morphometrics. Information derived from this exercise was extremely useful during Survey D (Leg II) when larval identifications were made for *E. frigida* and *E. triacantha,* previously lumped as *Euphausia* spp., as well as *E. crystallorophias.*

4.2.3 Statistical Analyses:

Data from the total survey area and four subareas are analyzed here for between-cruise and between-year comparisons. Analyses include a variety of parametric and nonparametric techniques. Among these are Analysis of Variance (ANOVA), Cluster Analysis, Percent Similarity Indices (PSIs) and Kolmogorov-Smirnov cumulative percent curve comparisons (D_{max}). Cluster analyses use Euclidean distance and Ward's linkage method; clusters are distinguished by a distance of 0.40 to 0.60. Clusters based on size characteristics utilize proportional length frequency distributions in each sample with at least 17 krill or 50 salps. Zooplankton clusters are based on log transformed sample abundance data for the most frequently occurring taxa. Statistical analyses were performed using Statistica software (StatSoft).

4.3 Results and Preliminary Conclusions:

4.3.1 Survey A, January-February 2002

4.3.1.1 Krill:

<u>Frequency and Abundance (Table 4.1A, Figure 4.1A)</u>

Postlarval krill were present in 71 of 95 survey samples (75%). They were most frequent in the Elephant Island Area where they occurred in all but five of 44 samples (89%); catch frequency ranged from 60-67% in other areas. The largest catch, from the South Area, contained nearly 4,000 individuals (1,477 krill per 1,000 m^3). Other large catches (i.e., >1,000 krill, estimated 400-700 per 1,000 m^3) were taken in all areas. Large concentrations were located over or offshore of shelves north of Livingston and King George Islands (Drake Passage), north of Joinville Island (Bransfield Strait) and northeast of Elephant Island Area. Krill abundance and distribution attributes varied regionally. Highest mean abundance in the South Area (161.7 per 1,000 m^3) resulted from three large catches, however, the large standard deviation and low median value (0.8 per 1,000 m^3) reflect generally sparse catches in this area. Mean abundance in the Elephant Island Area was comparatively low (39 per 1,000 m^3), but a relatively large median (7.5 per 1,000 m^3) and small standard deviation result from more uniform (i.e., less patchy) distribution. Moderately high concentrations characterized three of 9 Joinville Island Area samples and resulted in overall high mean and median values (respectively, 78.3 and 10.3 per 1,000 m^3). The West Area was characterized by patchy and generally low krill concentrations (mean and median, 42.0 and 0.4 per 1,000 m^3). Abundance differences among the four areas were not significant (ANOVA, P>>0.05 in all cases).

Length and Maturity Stage Composition (Table 4.2; Figures 4.2A & B; 4.3A-D; 4.4A-D)

Krill ≤33mm and ≥50mm, respectively, comprised 75% and 5% of the total catch. Accordingly, the maturity stage composition was 72% juvenile, 11% immature and 17% mature stages. South and Joinville Island Area krill were almost exclusively ≤38mm in length; size distributions centered around 24-25mm modes with a 26mm median and 90% ≤32mm. Juveniles representing the 2000/01 year class constituted 88-93% of individuals. Broader size ranges (16-60mm) and more heterogeneous length-maturity stage compositions were represented to the north, particularly in the West Area. Length distributions in the West Area were polymodal with peaks around 22, 25, 31, 36 and 53-55mm. This uneven pattern most likely results from extreme patchiness. While the primary mode was 25mm, the median (31mm) was 5mm larger than in the South and Joinville Island Areas and 15% of krill were ≥50mm. Accordingly, 57% were juveniles, 17% immature and 26% mature stages. Reproductively mature males (M3b) constituted 6% and females (F3a-3e) 20% of the total; 84% of these females were in advanced stages, predominantly gravid (F3d). Small juveniles also dominated Elephant Island Area catches (46%) but here 20-30mm lengths were equally represented with no obvious mode. This latter observation suggests successful recruitment from an extended spawning season the previous year. Larger krill centered about a 41-42mm mode and 20% of individuals were >45mm (i.e., ≥4 years old; Siegel, 1987). Immature and mature stages comprised 9% and 45%, respectively. Females outnumbered males by 60%; reproductively mature males comprised 10% and females 30% of the total. Most of these females (92%) were in advanced stages. Relatively large proportions of the Elephant Island population were gravid (10%) and spent (6%) females indicating active spawning in the area.

Distribution Patterns (Figures 4.5A; 4.6A & B)

Cluster analysis applied to length distributions in samples with ≥24 krill yielded three groups. Cluster 1 was represented at 13 stations primarily in the southeast portions of Bransfield Strait and Elephant Island Area. These were mostly 1 year-old krill: 90% were ≤33mm with 24-25mm modal length; juveniles comprised 89% and immatures 7% of the total. Cluster 2 occurred at 16 stations; although these were primarily over the South Shetland Island northern shelves and offshore of the Elephant Island shelf three were located in south and east Bransfield Strait. Lengths ranged from 18-59mm but centered around a 41-42mm (3 year-old) mode. Juveniles made up 16% and immature stages 26% of the total. Mature females outnumbered males; 16% had developing ovaries (F3c), 14% were gravid (F3d) and 6% spent (F3e). Cluster 3 was limited to seven Drake Passage stations and comprised predominantly (84%) large, mature individuals. Lengths were centered around 50 and 53mm modes, with a 49mm median, and represented 4 year-old (1997/98 year class) and older krill. Males and females were equally represented and actively reproductive: 43% stage 3b males; females with developing ovaries (12%), gravid (24%) and spent (2%).

4.3.1.2 *Salpa thompsoni:*

Frequency and Abundance (Table 4.1A; Figure 4.7A)

This ubiquitous salp was present in 88% of samples. It was most and least frequent in the West (96%) and Joinville Island (56%) Areas. Overall mean and median abundance values were relatively high (268 and 70 per 1,000 m^3, respectively); they were greatest in the Elephant Island (410 and 86 per 1,000 m^3) and South (201 and 71 per 1,000 m^3) Areas and lowest in the Joinville Island Area (184 and 2 per 1,000 m^3). Abundance differences are not significant due to large catch variability (i.e., large standard deviations) within each area (ANOVA, $P>0.05$).

<u>Composition, Size and Distribution (Figure 4.8)</u>

Aggregate (chain) forms constituted 98% of the overall catch and 97-100% in all but the West Area where solitaries comprised 8.5%. Solitaries were represented by a broad (4-120+mm) polymodal size range; median length was 38mm and 80% of individuals were <6 mm. Large, reproductively mature solitaries characterized the West and Elephant Island Areas where median lengths were 30 and 45mm, respectively. Median solitary lengths in the South and Joinville Island Areas were 5-6mm. While largest aggregates had 89-90mm internal lengths, the continuous size range extended from 4-74mm. Presence of extremely large aggregates indicate a particularly early onset of seasonal chain production (e.g., early August 2001, assuming a 0.44mm per day growth rate). Median aggregate lengths for the South, Elephant and Joinville Island Areas were 25-29mm suggesting a late November-early December production peak. Median aggregate length in the West Area was 43mm; overall length frequency distribution there was significantly larger than in the Elephant Island Area (Kolmogorov-Smirnov test, $P<0.05$). Peak production of these larger aggregates was probably a month earlier (i.e., in late October) than in other areas. Cluster analysis applied to lengths in all samples with >60 measured aggregates did not produce geographically coherent size groupings.

4.3.1.3 Zooplankton and Micronekton Assemblage:

<u>Overall Composition and Abundance (Tables 4.3, 4.4A, 4.5; Figures 4.9A & B, 4.10A & B)</u>

A total of 103 taxonomic categories (including 8 copepod species) were enumerated. Mean and median numbers of taxa per tow (19-20) were similar for the West, Elephant Island and South Areas; species richness within the Joinville Island Area was slightly higher (mean and median values 23 and 24 taxa per tow).

Copepods were present in all samples and comprised >67% of the catch. *Calanoides acutus* and *Calanus propinquus* were the most abundant taxa in all four areas and contributed 55% of total zooplankton. Greatest copepod abundance was in the West Area; significantly higher concentrations *C. acutus, Rhincalanus gigas, Pareuchaeta antarctica* and "other copepods" were located there than in other areas (ANOVA, $P<0.05$). Abundance of larval *Thysanoessa macrura* followed that of copepods overall and within West and Elephant Island Areas; West Area concentrations were significantly greater than in other areas (ANOVA, $P<0.01$ in all cases) and reflect their oceanic distribution. Aside from shared dominance by these taxa, zooplankton assemblages of the four areas differed. Mean and median abundance of ostracod and *Euphausia* spp. larvae ranked 2 and 3 in the Joinville Island Area. Within the South Area, postlarval *T. macrura, S. thompsoni* and krill respectively ranked 3, 4 and 5 in mean and median abundance. *Salpa thompsoni* ranked 3 and 4, respectively, in Elephant and Joinville Island Areas. The extremely high mean abundance value of radiolarians in the West Area gave them a rank of 3; based on medians, chaetognaths, the pteropod *Clio pyramidata sulcata* and amphipod *Themisto gaudichaudii* ranked 3, 4 and 5. Overall zooplankton abundance relations were most similar between West and Elephant Island Areas (PSI=79); those of the Joinville Island Area differed considerably from other areas (PSI=38-49). In addition to different abundance relations of dominant taxa, the Joinville Island Area included unidentified larval and postlarval decapods, crustacean larvae, various jellies and larval fish species many of which are associated with the Weddell Sea.

Larval krill were relatively rare; the 19.4 per 1,000 m^3 mean abundance value was similar to that of postlarval *E. frigida* and *E. crystallorophorias* (ranked 12-14 overall). Greatest concentrations were in the Elephant Island and South Areas (respective means of 35.8 and 13.3 per 1,000 m^3); they were quite sparse in the West Area (1.5 per 1,000 m^3 mean). Unlike previous years, there was no significant positive relationship between larval krill and total copepod abundance (Kendalls Tau, $P>0.05$). It is quite likely that the abundant *Euphausia* spp. larvae in the Joinville Island Area (985$\pm$248 and 69 per 1,000 m^3 mean, standard deviation and median, respectively) were krill. Larval krill stages ranged from early Calyptopis (C1) to early Furcilia (F2). Overall stage composition was: (C1) 37%; (C2) 16%; (C3) 17%; (F1) 10%; and (F2) 20%. Relatively large proportions of both Furcilia and C1 stages indicate an early and prolonged spawning season. Relative proportions of calyptopis and furcilia larvae differed in each area (Table 4.5): calyptopis stages comprised 100% in the West and 77% in the Elephant Island Areas; furcilia were 79% in the South Area. Larval *Euphausia* sp. in the Joinville Island Area were primarily C3 (52%) and F1 (38%).

Distribution Patterns (Table 4.6; Figure 4.11A)

Cluster analysis applied to abundance [Log (N+1)] of taxonomic categories (minus larval krill and *Euphausia* sp.) in ≥13% of samples resulted in three groups with more or less obvious hydrographic affiliations. Cluster 1 was present at 15 Drake Passage stations well offshore of the South Shetlands and Elephant Island, within Type 1 (or Water Zone I) "Oceanic" water. "Coastal" Cluster 3 occurred at 39 stations in predominantly Type 4 (Water Zone IV) and Type 5 (Water Zone V) waters within and downstream of Bransfield Strait. Cluster 2 was represented at 41 stations, generally over or adjacent to island shelves, characterized by mostly Type 2 (Water Zone II) and 3 (Water Zone III) waters. In addition to water zone affiliations, the distribution patterns reflected prevailing water transport and eddies seen in dynamic height plots (See Physical Oceanography section in this report). Notable among these are associations with regularly observed gyres offshore of King George Island and within the Joinville Island Area.

Overall zooplankton abundance in Oceanic Cluster 1 was an order of magnitude greater than in the other two clusters and, among the 12 dominant taxa, only that of *S. thompsoni* was not significantly higher (ANOVA, P generally <0.01). Shared dominance by, and abundance relations of, *C. acutus, C. propinquus, T. macrura* larvae, *M. gerlachei* and *R. gigas* resulted in similar overall compositions of Clusters 1 and 2 (PSI=80). Aside from overall and individual species abundance values Cluster 1 differed from Cluster 2 by having large numbers of radiolarians. Coastal Cluster 3 differed substantially from these (PSIs=48-50) due to more even abundance relations (i.e., less extreme dominance by a few taxa) and comparatively large proportions of postlarval *T. macrura, M. gerlachei* and *S. thompsoni*. Abundance of *T. macrura* and *S. thompsoni* were significantly higher than in Cluster 2 (ANOVA, $P<0.05$).

4.3.1.4 Survey A Between-Year Comparisons:

Krill (Tables 4.7, 4.8, 4.9)

Within the 1991/02-2001/02 Elephant Island Area data set January 2002 krill abundance values were relatively high; the mean ranked 2 and median 4 over the 11-year data set. These values were most similar to those of 1994 (mean and associated standard deviation) and 1993 (median). Modest abundance increases over 2001 resulted from recruitment of the 2000/01 year class which offset loss of older individuals, most notably remnants of the highly successful 1994/95 year class that has dominated catches for the past six years. Assuming that the Elephant Island Area is representative of the northwest Antarctic Peninsula region, the large proportion of juveniles (46%), second only to that of 1996 (55%), indicates substantial recruitment from last years spawn. Relatively small proportions of two year old intermediate sized (34-40mm) and immature forms (9%) here (as well as the other areas) support last year's observations of low 1999/00 year class success. Overall maturity structure was most similar to that of 1992 (PSI=90).

Although mean and median krill carbon biomass in the Elephant Island Area (219 and 38mg C per m^2) were similar in magnitude to values of January-February 1995-1997 and 2001 they both ranked among the lowest recorded over the seven years for which data are available. This reflects the shift in dominance from large mature stages to small juveniles.

The adult population was actively spawning during Survey A with >91% of mature females in advanced stages. This is comparable to the situation in 1994/95, 1995/96 and 1998/99 where 93-98% were in advanced stages. Mean larval krill abundance and maximum catch size were relatively high and similar 2000/01 values. However, these numbers are low compared to those of 1994/95 and 1998/99. Presence and relatively large proportions of furcilia stages have previously been noted only during Survey A in 1998 indicates a very early initiation of spawning (e.g., late November-early December) compared to other years.

Salps (Tables 4.7, 4.9; Figures 4.11F, 4.14)

Salpa thompsoni mean and median abundance values in the Elephant Island Area, like those of 1996/97, were moderate compared to extreme highs in 1992/93 and 1993/94 and lows in 1994/95 and 1995/96. The stage composition, with 98% aggregate forms, is typical for January-February surveys. The broad aggregate size range, median length and length-frequency distribution most resembled those of 1996/97. Accordingly, mean and median salp carbon biomass values (219 and 38mg per m^2) were most similar to those of 1996/97. The median salp:krill carbon biomass relation (3.4) was similar to the moderate value of 2000/01 (3.1).

Zooplankton Assemblage (Tables 4.5, 4.7, 4.10, 4.11A, 4.12A, 4.13)

Increased diversity over previous years can be attributed to (a) extended sampling areas, (b) a more protective cod-end, (c) refined identification techniques and (d) inclusion of more unidentified ("unid.") categories. Mean and median numbers of taxa per tow for the total survey, West and Elephant Island Areas (19-20) were similar to those of 2000/01 whereas the South Area value (19 taxa per tow) was substantially less (25 taxa per tow). Overall mean Survey A abundance of various taxa was highest recorded since 1994/95 and resulted from large concentrations within one or more areas: Copepods (notably *C. acutus* and *C. propinquus*), radiolarians and *Clione limacina* (West and Elephant Island Areas); *Clio p. sulcata* (West and Elephant Island Areas); *Primno macropa* and *E. frigida* (Elephant Island and South Areas); ostracods and larval *Lepidonotothen larseni* (Joinville Island and South Areas); and *E. crystallorophias* (South Area). Abundance of *Ihlea racovitzai* (predominantly in the Joinville Island Area) was low relative to 1997/98 and 1998/99 and similar to that of 2000/01.

Within the Elephant Island Area copepod abundance was the greatest observed over the 9-year period for which there are AMLR data. The mean >5X greater than peak values of January-February 1996, 1999 and 2001; the median was one to two orders of magnitude greater than previously observed. These values, more like seasonally elevated ones of February-March, were due to extremely large concentrations of *C. acutus* and *C. propinquus*, both of which are oceanic species. As during 1999, abundance of coastal *M. gerlachei* was low compared to other January-February surveys. Among other dominant taxa, mean and median abundance of larval *T. macrura*, postlarval *E. frigida* and chaetognaths were also the largest encountered during AMLR surveys. Extreme patchiness led to high mean abundance of postlarval *T. macrura*, but its median value ranked 5 out of 9. While mean larval krill abundance ranked third in the 7 years for which there are data it was only about 20% values of January-February 1995 and 1999. Calyptopis stages usually constitute the vast majority of larvae sampled during early summer; similar, relatively large proportions of furcilia stages (68%) were only noted during 1998 Survey A.

Numerical dominance of the zooplankton assemblage by copepods (76% of individuals) was the most extreme observed over the 9 year period. This dominance resulted in moderately high PSI values (71-77) in comparisons with January 1995, 1996, 1997 and 1999 and low values (14-15) in comparisons with 1994 and 1998 when salps were by far the dominant taxon. Rankings of the five most abundant taxa (copepods, larval and postlarval *T. macrura*, *S. thompsoni*, and chaetognaths) were most similar to those of January 2001.

4.3.2 Survey D, February-March 2002

4.3.2.1 Krill:

<u>Frequency and Abundance (Table 4.1B; Figure 4.1B)</u>

Postlarval krill were present in 54 of 94 Survey D samples (57%) and had overall mean and median abundance values of 281 and 0.5, respectively. The largest catch (ca. 22,000 individuals, 7,566 per 1,000 m^3) was in southwest Bransfield Strait, in proximity to the Gerlache Strait. Two other large catches (ca. 11,000 and 2,100 individuals, 7,323 and 9,319 per 1,000 m^3) were located inshore north of Livingston and King George Islands. Two moderately large concentrations (534-660 per 1,000 m^3) were sampled in the northeast Joinville Island Area. As a result of scattered concentrations and differing distribution attributes, frequency of occurrence, mean and median abundance relations differed within most areas. Krill were most frequent in the Joinville Island Area (89%) where median abundance (1.7 per 1,000 m^3) ranked second to that in the South Area (6.4 per 1,000 m^3), but the mean was smallest (4.3$\pm$ 5.4 per 1,000 m^3). In the West Area krill were least frequent (46% of samples), had the lowest median (0), but largest mean abundance (694$\pm$2,318 per 1,000 m^3). Frequency of occurrence (54%), mean and median abundance values (10.1$\pm$25.4 and 0.4 per 1,000 m^3) in the Elephant Island Area ranked third to those of other areas.

Length and Maturity Stage Composition (Table 4.2; Figures 4.12, 4.13A-D, 4.14A-D)

Small krill overwhelmingly dominated Survey D catches. The median length was 28mm, 10% were $\geq$38mm, and only a few individuals were >45mm. Accordingly, juveniles comprised 73% and immature stages 25% of the total. Predominantly small krill were collected in the West and South Areas, with those in the South (24mm mode, 25mm median and 5% $\geq$38mm) being slightly smaller than in the West Area (27mm mode, 29mm median and 10% $\geq$38mm). In the South and West Areas, respectively, juveniles made up 77% and 72%, immatures 23% and 27% and mature stages <1% and 1% of the total. Broader size ranges, larger median lengths and polymodal distributions were represented in the other areas. Within the Elephant Island Area lengths were distributed around 29-32mm, 42mm and 52mm modes, which probably correspond to 1, 3 and 5+ year old (i.e., 2001, 1999 and 1995 year classes); the median length was 36mm. Juveniles made up 39%, immatures 17% and mature forms 44%. Males outnumbered females by 50%, but sexually mature stages were fairly evenly represented (22% vs. 21%); most females were gravid or spent (85%) suggesting the end of the spawning season. In contrast, krill lengths in the Joinville Island Area were not centered around distinct modal sizes corresponding to age/maturity categories. Juveniles with 22, 25 and 27mm modes constituted 46% of the individuals; immature and mature stages were fairly evenly represented (28 and 26%, respectively). Although males and females were equally abundant virtually all males were immature and the mature stages were mostly gravid (16%) and spent (6%) females. Only within this area were 2-year-old krill (ca. 38mm mode representing the 2000 year class) relatively abundant.

Distribution Patterns (Figures 4.5B, 4.6C & D)

As during Survey A, cluster analysis (applied to 22 samples with $\geq$15 krill) yielded three geographically distinct length/maturity groups. Cluster 1 was represented at six stations south of the South Shetland Islands in west Bransfield Strait. These were predominantly juveniles (86%) with lengths centered around a 22-26mm mode. Immature forms comprised 12% and mature stages 2%. The median length was 25mm and 98% of individuals were $\leq$ 40mm. Cluster 2 occurred at 10 stations, mostly within Bransfield Strait, to the north and northeast of Cluster 1. Juveniles were again the dominant stage (48%), but these were larger, centered around a 27-29mm mode. The median length was 32mm and 16% of individuals were >40mm. Immature stages comprised 31% and included small (32-33mm, stage 2A) males as well as larger, regressing post spawning individuals (male 2c, 3a; female 2, 3a). Mature stages made up 21%; gravid and spent females (3d and 3e) were the most abundant (13% of total). Cluster 3 included six stations located over the South Shetland and Elephant Island shelves and was dominated (85%) by mature forms while juveniles made up 6% and immature stages 9%. The median length was 44mm, 10% of individuals were <32mm and 25% were >50mm. Lengths were primarily centered around 42-44mm, 48-49mm, 52 and 55mm modes representing 3-5+ year old krill. Overall, females outnumbered males by 40%. Mature males comprised 35% and gravid and spent females 53% of the total. Maturity stage composition and southern distributions of Cluster 2 and 3 reflected completion of the spawning season (Siegel, 1988).

4.3.2.2 *Salpa thompsoni*:

Abundance (Table 4.1B; Figure 4.7B)

Salps were collected at 76 Survey D stations (81%). Mean and median abundance values were 622 and 59 per 1,000 m^3, respectively. As with krill, a large standard deviation ($\pm$1,372) reflected uneven distribution across the survey area. Greatest concentrations, estimated to be 10,000-20,000 individuals and 4,757-8,756 per 1,000 m^3, were encountered at offshore Drake Passage stations in the West Area and resulted in a high mean value (1,217 per 1,000 m^3); the median was relatively low (24 per 1,000 m^3) due to patchiness. Within the Elephant Island Area largest salp concentrations (>2,000 per 1,000 m^3) were also associated with oceanic water but similar mean and median abundance values (570 and 250 per 1,000 m^3, respectively) reflected elevated and more evenly distributed concentrations. Salps were patchy and much less abundant in the South and Joinville Island Areas (means ca. 160 per 1,000 m^3, medians 2-8 per 1,000 m^3).

Maturity Stages, Size and Age (Fig. 4.8)

Aggregates again contributed the majority (96%) of individuals collected overall. Solitaries were rare (<2%) in the West and South Areas; they constituted 8% and 5% of the catch in the Elephant and Joinville Island Areas. In the Joinville Island Area these solitaries were primarily small, recently spawned forms <25mm; in the West and Elephant Island Areas they were primarily larger, actively budding individuals. Coincidentally, the majority of aggregates in the West (85%) and Elephant Island Areas (65%) were <20mm, with 12-15mm median and 10mm modal lengths. These resulted from a late season pulse of budding activity. Without this chain production, median and modal aggregate lengths were much larger in the South (23mm and 20mm) and Joinville Island Areas (44mm and 48mm).

Distribution Pattern (Fig. 4.15A,B)

In contrast to Survey A, cluster analysis (applied to aggregate length distributions in samples with $\geq$50 specimens) yielded two distinct, geographically coherent groups. Cluster 1 occurred at 36 stations, 30 of which were associated with Water Zones I and II over outer island shelves and offshore. The remaining six stations were associated with Zone V (continental shelf) water south of the South Shetland Islands within Western Bransfield Strait. This cluster was composed primarily of small individuals (80% $\leq$30mm, 16mm median) released within the past month. Cluster 2 aggregates occurred at 18 stations, most of which were over King George and Elephant Island shelves and associated with Water Zones III and IV. These were primarily large, sexually mature individuals (80% $\geq$35mm, 44mm median) presumably ready to produce the overwintering solitary form; recent aggregate chain production was essentially absent here. Size distributions of the two clusters were significantly different (K-S test D_{MAX}=66.1 at 34mm, P<0.01).

4.3.2.3 Zooplankton:

Overall Composition and Abundance (Tables 4.3, 4.5, 4.10B, 4.11B, 4.12, 4.13B; Figures 4.9C & D, 4.10C & D)

Survey D samples yielded a total of 93 taxonomic categories; overall mean and median values were 18 taxa per tow. Again, species richness was modestly greater in the Joinville Island Area (mean and median values 23 and 24 vs. 19-20 taxa per tow in other areas). Copepods remained the most frequently occurring (100% samples) and numerically dominant taxon (58% of individuals) with species abundance relations similar to those during Survey A (i.e., *C. acutus*>*C. propinquus*>*M. gerlachei*>*R. gigas*). Greatest mean and median copepod abundance was in the West Area followed by Elephant Island, Joinville Island and South Areas. This was primarily due to extremely large offshore concentrations of *C. acutus* and *C. propinquus*. Among copepod categories, West Area abundance of *C. propinquus* and *R. gigas* was significantly higher than in the South Area (ANOVA, P=0.03) and of copepodites was significantly higher than in Elephant Island (P<0.01) and South (P=0.04) Areas.

Although radiolarians occurred in only 36% of samples their mean abundance ranked second to copepods (7,900 vs. 15,900 per 1,000 m^3) due to extraordinarily large (to 200,000 per 1,000 m^3) primarily offshore concentrations. Larval *T. macrura* and chaetognaths were present in 97-98% of samples and overall ranked 3-4 in mean and 2-3 in median abundance. These were followed by *S. thompsoni* (81% of samples, 2.3% total mean abundance) and postlarval krill (1% mean abundance). *Themisto gaudichaudii* was present in 98% of samples and had a relatively large median value (17 per 1,000 m^3); its West Area abundance was significantly greater than in Elephant Island and Joinville Island Areas (ANOVA, P=0.02). Postlarval *T. macrura* and *E. frigida* were also relatively frequent (80% and 66% of samples) with relatively large medians (11 and 6 per 1,000 m^3). Bransfield Strait centered distributions are reflected in significantly greater South Area vs. Elephant Island Area abundance of *T. macrura* (P=0.02), *E. crystallorophias* (P=0.04) and ostracods (P=0.02).

Larval krill were present in 29% of samples with respective mean and median values of 61 and 0 per 1,000 m^3. C1 through F2 stages were collected. Calyptopis stages comprised 85% of the total with C3 dominant (50%). Greatest concentrations occurred in the West Area (mean 134 per 1,000 m^3) followed by Elephant Island, Joinville Island and South Areas (50, 29 and 4 per 1,000 m^3, respectively). Virtually all West and South Area larvae were calyptopis stages, predominantly C3 (70%) in the West and C1 and C2 (50% each) in the South. Calyptopis stages comprised 70% of Elephant Island Area larvae (C1=42%, C3=24%); 23% were F1. Calyptopis and furcilia larvae were more evenly represented in the Joinville Island Area due to similar proportions of C3 (30%) and F1 (27%).

Larval and postlarval stages of all five euphausiid species showed differing distribution patterns and relationships. Distributions of larval and postlarval krill were independent of each other.

While *T. macrura* larvae were collected in all four areas their offshore concentrations resulted in a strong negative correlation with postlarvae (Kendall's Tau T=-0.26, P<<0.01); this pattern has been described in previous AMLR field season reports. Larval *E. frigida* were also broadly distributed but most frequent and abundant in the South and Elephant Island Areas; like krill there was no apparent relationship between distributions of larval and postlarval stages. Although mean abundance of larval *E. crystallorophias* was highest in West and Elephant Island Areas they were most frequent in South and Joinville Island Areas; adults were almost exclusively collected in the South and overall catches of the larval and postlarval stages were positively correlated (T=+0.17, P=0.02). Because of their predominantly South Area presence, postlarval *E. crystallorophias* also had a significant positive correlation with larval *E. frigida* (T=+0.20, P<0.01) and negative correlation with larval *T. macrura* (T=-0.33, P<<<0.01). Concentrations of larval and postlarval *E. triacantha,* predominantly in the West, resulted in a significant positive correlation (T=+0.16, P=0.02), however, the overall distribution of *E. triacantha* postlarvae was most like that of larval *T. macrura* (T=+0.23, P<<0.01).

Abundance relationships between calyptopis and furcilia stage krill larvae and other zooplankton taxa suggest differing source areas. Pooled calyptopis larvae were positively correlated with two types of fish larvae, *Leptonotothen kempi* (T=+0.17, P=0.01) and *Electrona* spp (T=+0.15, P=0.03), and copepodites (T=+0.16, P=0.03); these taxa co-occurred primarily in Zone II water adjacent to the outer shelf. Five of 8 samples with furcilia larvae were also primarily adjacent to outer shelf in Zone II and III water. The other three samples were in the east Joinville Island Area (Zone V water) where abundant furcilia co-occurred with *Ihlea racovitzai* and *Limacina helicina* (T=+0.24 and +0.26, P<<0.01). These taxa were probably advected into the Joinville Island Area from the Weddell sea. As during Survey A, there was no significant positive correlation between larval krill and total copepod abundance (Kendalls Tau, P>0.05).

<u>Distribution Patterns (Table 4.15; Figure 4.11B)</u>

Cluster analysis (applied to taxa present in >20% of samples) yielded two groupings. Cluster 1, the smallest of these, was represented at 29 stations, 21 of which were over or offshore of the outer shelf. Although this distribution encompassed water Zones I-IV it appeared to reflect onshore-offshore dynamics associated with the strong oceanic eddy (See Physical Oceanography section of this report). Cluster 2 was represented at the remaining 65 shelf and coastal stations. The 23 taxonomic categories were included in both clusters and, except for radiolarians (almost exclusively in Cluster 1), shared similar abundance relationships. This is evidenced by PSI values for comparisons with (60.2) and without (83.6) radiolarians. Only one category, postlarval *T. macrura*, was significantly more abundant in Shelf-Coastal Cluster 2 (ANOVA, P=0.02). There was no significant difference between Cluster 1 and 2 abundance of eight taxa (*E. frigida*, larval and postlarval *E. superba*, ostracods, *T. gaudichaudii*, *Hyperiella dilatata, Cyllopus magellanicus* and *Spongiobranchaea australis*). Abundance of the remaining 14 taxa was significantly higher in Oceanic Cluster 1 (ANOVA, P<0.05).

4.3.2.4 Survey A and D 2002 Comparisons:

<u>Krill (Tables 4.2, 4.3, 4.7-4.9; Figures 4.1-4.6, 4.12-4.14)</u>

Seasonal differences in krill catch frequency and abundance resulted from changes in their distribution patterns and attributes. Overall decreased frequency of occurrence, substantially increased mean and standard deviation values and decreased median are the consequence of increased patchiness. This was associated with a significant proportional decrease of krill >40mm (K-S test, $p<0.01$), decline in proportions of mature vs. immature stages, and substantial changes in length/maturity characteristics within the survey areas. Between Surveys A and D, mean krill abundance increased in West and South Areas and decreased in Elephant and Joinville Island Areas, however only the Elephant Island Area decrease was significant (Z test, $P<0.05$). Increased abundance in the West Area was associated with elevated concentrations of juvenile and immature krill of 25-42mm lengths; that in the South Area was associated with increased concentrations of 20-24mm juveniles and >31mm immature stages. Despite marked abundance decreases, overall maturity stage composition did not change much in Elephant Island and South Areas (PSIs=92 and 89, respectively) compared to the West (75) and South (54) Areas.

Shifting distributions of length/maturity categories are seen in comparisons of Survey A and D krill clusters. Cluster 1 demographics (predominantly small juveniles) are quite similar for both surveys (stage PSI=96), but its distribution contracted from a broad Bransfield Strait presence to one limited to the western Strait. Cluster 3 stage composition (predominantly large mature animals) was also quite similar between the surveys (stage PSI=95), but the length composition showed increased proportions of 3+ krill (40-46mm) relative to larger, older age classes. This group demonstrated an onshore seasonal distribution change. Cluster 2 demonstrated large changes in both size and maturity composition (length $D_{MAX}=46$, stage PSI=63) which reflected a shift from predominantly mature 3+ krill (now partially incorporated into Cluster 3) to a mixture of large juvenile (1+), immature (2+) and mature (3+) individuals. As with the other groups, Cluster 2 distribution had a southward seasonal shift to the location of Cluster 1 during Survey A. As a result of seasonal migration, particularly by large individuals, krill carbon biomass in the Elephant Island Area was substantially (but not significantly) reduced.

Salpa thompsoni (Tables 4.3, 4.7; Figures 4.7, 4.8, 4.15)

The overall doubling of mean salp abundance during Survey D was attributed to the West Area where the mean was 13 times that of Survey A. This significant increase (Z test, $P<0.05$) was due to extremely large offshore concentrations of recently budded aggregates. Mean and standard deviation values in the Elephant Island Area were similar during the two surveys; an order of magnitude increase in median abundance resulted from 26 vs. 21 relatively large catches during Survey D. Cluster analysis results and length-frequency distributions during Survey D indicate that large, mature solitaries in Drake Passage (and to a lesser extent western Bransfield Strait) had migrated to surface layers for a late season pulse of aggregate chain production (Foxton, 1966; Casareto and Nemoto, 1986). Because of aggregate growth and presence of large solitaries median salp carbon biomass in the Elephant Island Area more than doubled between the two surveys. This increase in conjunction with decreased median krill biomass led to a substantial change in their ratio, from ca. 3:1 to 120:1.

Zooplankton (Tables 4.3-4.6, 4.10-4.15; Figures 4.9-4.11)

Ten fewer taxa were identified during Survey D, primarily the result of fewer unidentified crustacean categories. This decrease, plus lower mean and median values of species richness, could reflect a seasonal reduction in mesoplanktonic taxa. Total copepod abundance was significantly greater during Survey D (Z test, $P<0.01$) and resulted primarily from eastward expansion of extremely large offshore concentrations across much of the survey area. Increased copepod concentrations also were located in Bransfield Strait, presumably associated with retention systems south of King George and Livingston Islands and in the Joinville Island Area. Overall increased copepod abundance was largely due to *C. acutus, M. gerlachei* and *R. gigas* (ANOVA, $P<0.05$). In addition to copepods and salps, radiolarians and chaetognaths had significant abundance increases between the two surveys (ANOVA, $P<0.05$); postlarval *T. macrura*, ostracods and *Clio p. sulcata* had decreased abundance during Survey D but only that of *C. p. sulcata* was significant ($P<0.001$). Due to the huge mean abundance increase of radiolarians the proportional contribution by copepods to total zooplankton decreased from 68% to 58% between surveys and resulting PSI was 77 (72 if individual taxa are used vs. total copepods).

Among the dominant taxa chaetognaths were the only category with significant seasonal abundance increases within all four areas ($P<0.02$). Significant increases were observed for: *C. acutus, M. gerlachei, R. gigas, C. p. sulcata* and radiolarians (Elephant Island Area); *C. acutus, C. propinquus* and *E. frigida* (Joinville Island); *M. gerlachei* and *T. gaudichaudii* (South Area); and "other" copepods, *E. triacantha, Primno macropa, Vibilia antarctica* and *S. thompsoni* (West Area). Significant abundance decreases ($P<0.001$) occurred for larval *T. macrura* (West Area) and *C. p. sulcata* (West and Elephant Island Areas).

Mean larval krill abundance increased 3 times, between Surveys A and D and was associated with increased proportions of C3 vs. earlier stages. Greatest change was in the West Area where the mean (mostly C3 larvae) was two orders of magnitude greater than the previous month (134 vs. 1.5 per 1,000 m^3). Larval krill in the Elephant Island Area demonstrated a modest mean abundance increase (50 vs. 36 per 1,000 m^3) associated with a shift to greater proportions of C3 and F1 vs. younger stages. Decreased abundance in the South Area (13 to 4 per 1,000 m^3) was associated with loss of F1 and F2 stages. If the Survey A *Euphausia* sp. larvae in Joinville Island Area were largely *E. superba*, then mean abundance there had a large seasonal decrease (ca. 980 vs. 29 per 1,000 m^3) associated with a shift to greater proportions of F2 and F3 stages. Larval *E. frigida, E. crystallorophias* and *E. triacantha* were not identified during Survey A. During Survey D, larval *E. frigida* and *E. crystallorophias*, respectively, ranked 11 and 16 in overall mean abundance while *E. triacantha* larvae were fairly rare.

Marked changes in zooplankton clusters between the two surveys reflect (a) increased abundance and onshore expansion of Oceanic taxa and (b) blending of Shelf and Coastal taxa with little effect on their pooled abundance. Seasonal population growth along with intensified advective and mixing processes associated with the offshore gyre and Antarctic Circumpolar Current are likely forces behind these changes.

4.3.2.5 Survey D Between-Year Comparisons:

<u>Krill (Tables 4.7B, 4.8, 4.9)</u>

In stark contrast to Survey A, krill mean and median abundance values in the Elephant Island Area during February-March 2002 were among the lowest recorded over the past 11 years and resembled those of 1994 and 1995. Accordingly, low krill carbon biomass values matched those of 1995. Relatively large proportions of juveniles (39%), like 1992 and 1996, indicate good recruitment success of the previous year class. As during 2001, proportions of immature stages indicate only modest recruitment success from two years ago (1999/00). Maturity stage composition most resembled that of 1992 (PSI=90). Poor recruitment success since the 1995/96 year class together with age-related mortality are undoubtedly responsible for population size decrease. However, considering Survey A results, the magnitude of this decline may be magnified by seasonal migration away from the area. Large proportions of advanced female maturity stages have characterized the past four years and are in distinct contrast to 1992-1994 and 1998 when normal seasonal spawning did not appear to take place. The male to female ratio (1.5) is typical of that during 1992-1998 and contrasts with 1999-2001 when females outnumbered males.

Salps (Tables 4.7, 4.9; Figure 4.16)

Mean and median salp abundance in the Elephant Island Area during February-March has remained fairly stable since 1999; these values are approximately half those during highs in 1993, 1997 and 1998. However, the means are an order of magnitude, and medians two to three orders of magnitude, greater than during the 1995 and 1996 copepod years. The broad size range and late season pulse of small aggregate production yield a length frequency distribution quite similar to that of March 1997 ($D_{MAX}<10$). In the past, late season production has presaged salp blooms the following summer. As with abundance, Survey D salp carbon biomass has remained fairly stable since 1998. In contrast, the salp:krill biomass ratio of 120:1 is unprecedented and reflects apparent migration of krill out of the survey area.

Zooplankton (Tables 4.5, 4.7, 4.9B, 4.10B, 4.11B)

For the same reasons listed for Survey A, substantially more taxa were collected this year (83 vs. 57-62). However, mean and median numbers of taxa per tow in the West and Elephant Island as well as South Areas (17-19) were smaller than those during 2001 Survey D (20-25) suggesting a seasonal decrease in species richness. Overall mean abundance of a number of taxa was substantially greater than reported from previous February-March surveys due to their large concentrations in one or more areas: Copepods (notably *C. acutus* and *M. gerlachei*) and chaetognaths (all four areas); *Themisto gaudichaudii* and *P. macropa* (West, Elephant and South); radiolarians, larval *T. macrura* and *Vibilia antarctica* (West and Elephant); *Hyperiella dilatata* (West, Elephant and Joinville); *E. frigida* (West); *E. crystallorophias* and larval *L. larseni* (South).

Copepod abundance in the Elephant Island Area was the highest observed during February-March AMLR surveys with mean and median values 2 times the highs of 2000. Due to summer spawning *M. gerlachei* joined *C. acutus* and *C. propinquus* in being primarily responsible for these elevated concentrations. Mean and median abundance values of *C. acutus* exceeded, and those of *C. propinquus* were comparable to, those recorded during the krill "superswarm" year 1984; *M. gerlachei* abundance was comparable to the highs of 2000. Postlarval *T. macrura* abundance was among the lowest reported since 1993. Like postlarval krill, this euphausiid was much less abundant here (as well as West and South Areas) than during Survey A suggesting movement out of the upper water column and/or area. Like copepods, larval *T. macrura* and chaetognaths were more abundant than during previous AMLR surveys. Larval krill mean abundance ranked five in the 8 years of data available. This is not particularly bleak, given (a) seasonally increased abundance and advanced development and (b) relatively large proportions of C3 and F1 stages.

Copepods have numerically dominated the Elephant Island Area during all February-March surveys except 1995 when larval krill were extraordinarily abundant and the 1998 salp year. Such extreme dominance (>80% of individual zooplankters) was most similar to 1994 (PSI=86). Overall species abundance relationships were fairly consistent with those over the past three years and during 1996 (PSI=70-79) with copepods, larval *T. macrura*, chaetognaths and salps being the most abundant taxa. *Salpa thompsoni* has remained the fourth ranked taxon over this period

4.3.3 AMLR 2001/02 Cruise Summary:

(A) Mean and median krill abundance in the Elephant Island Area during January was relatively high and, respectively, ranked 2 and 4 in the 1992-2002 data set; the February-March values were among the lowest recorded. These differences resulted from seasonal distribution changes across the large survey area.

(B) Small juveniles, representing successful recruitment of the 2000/2001 year class, numerically dominated catches in the Elephant Island, Joinville Island, South and West Areas during Surveys A and D.

(C) Relatively small proportions of two-year-old intermediate sized immature forms in all four areas support last year's observations of low 1999/2000 year class success.

(D) Larval krill were moderately abundant in the Elephant Island Area. Relatively large proportions of furcilia and early calyptopis stages during both surveys indicate a very early initiation (e.g., late November-early December) and prolonged spawning season compared to other years. A modest seasonal abundance increase in conjunction with increased proportions of advanced developmental stages bodes well for recruitment success of the 2001/2002 year class.

(E) *Salpa thompsoni* abundance in the Elephant Island Area was moderately high and similar to values observed in 1999-2001. A late season pulse of chain production may presage a salp bloom during 2002/03.

(F) Greatly increased zooplankton diversity over previous years resulted from the expanded survey area, a more protective cod-end and refined identification techniques. Species richness was highest in the Joinville Island Area influenced by the Weddell Sea.

(G) Copepods (notably *Calanoides acutus*, *Calanus propinquus* and *Metridia gerlachei*), were by far the most abundant zooplankton category; their mean and median abundance values were by far the highest encountered during AMLR surveys. Concentrations of larval *Thysanoessa macrura*, postlarval *Euphausia frigida* and chaetognaths were also the highest recorded.

4.4 Disposition of Data and Samples: All of the krill, salp and other zooplankton data have been digitized and are available upon request from Valerie Loeb. These data have been submitted to Roger Hewitt (Southwest Fisheries Science Center). Frozen krill and myctophids were provided to Mike Goebel and Dan Costa (UCSC) for chemical analyses.

4.5 Problems and Suggestions: Expansion of the large survey area across Bransfield Strait into areas directly influenced by west Antarctic Peninsula, Gerlache Strait and Weddell Sea dynamics has greatly improved our ability to link biological and hydrographic processes within the South Shetland-Elephant Island Area. This is especially important in that the warming environment and glacial retreat, especially in the western Weddell Sea, may already be altering krill distribution, behavior and population dynamics. We strongly urge development of a coordinated research effort, possibly within CCAMLR, to provide base line data on recently opened pelagic (i.e., seasonal sea ice) and benthic (i.e., virgin fish stock) habitats in the western Weddell Sea.

Again it was extremely helpful to have the expert assistance of CTD technicians at sea. However, we are still handicapped by the lack of an experienced physical oceanographer who can provide real time information on water mass distribution and dynamics. With regard to hydrodynamics, it would be extremely beneficial to have information provided by an acoustic Doppler current profiler. This is especially true for examining transport of krill larvae in relation to recruitment success in the survey area and advection to South Georgia.

The zooplankton van would benefit from modifications making it more comfortable and more easily maintained for use by both the krill and fish stock assessment surveys. Improvements would include (a) replacing storage areas with microscope benches allowing assistants to be seated while performing sample analyses and (b) installation of stainless steel counters to allow efficient and effective cleaning.

4.6 References:

Makarov, R.R., and Denys, C.J.I. 1981. Stages of sexual maturity of *Euphausia superba*. BIOMASS Handbook 11.

Physical Oceanography Report. This volume.

Siegel, V. 1987. Age and growth of Antarctic Euphausiacea (Crustacea) under natural conditions. *Marine Biology* 96: 483-495.

Siegel, V. 1988. A concept of seasonal variation of krill (*Euphausia superba*) distribution and abundance west of the Antarctic Peninsula. Pp. 219-230 *In*: D. Sahrhage (ed.) Antarctic Ocean and Resources Variability. Springer-Verlag, Berlin.

Table 4.1. AMLR 2002 Large-area survey IKMT station information. Double lines denote subarea divisions.

A. SURVEY A

STATION #	DATE	TIME START (LOCAL)	TIME END (LOCAL)	DIEL	TOW DEPTH (m)	FLOW VOLUME (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/1000M3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000M3
SOUTH AREA										
A15-15	15/01/02	2311	2331	T	171	1976.7	0	0.0	83	42.0
A16-14	16/01/02	0219	0242	N	171	2377.3	0	0.0	180	75.7
A17-13	16/01/02	0522	0549	D	171	2575.1	2	0.8	88	34.2
WEST AREA										
A18-12	16/01/02	0837	0900	D	171	2307.6	40	17.3	0	0.0
A19-11	16/01/02	1204	1228	D	170	2428.1	14	5.8	7	2.9
A20-10	16/01/02	1605	1633	D	170	2635.6	0	0.0	26	9.9
A19-09	16/01/02	1925	1949	D	171	2466.7	1	0.8	1720	697.3
A18-10	16/01/02	2255	2317	N	171	2161.0	0	0.0	344	159.2
A17-11	17/01/02	0206	0225	N	115	2031.7	1455	716.2	186	91.6
A16-10	17/01/02	0501	0528	D	170	2544.2	127	49.9	3	1.2
A17-09	17/01/02	0819	0840	D	171	2034.4	28	13.8	59	29.0
A18-08	17/01/02	1152	1215	D	170	2116.4	0	0.0	244	115.3
A17-07	17/01/02	1531	1555	D	170	2512.5	0	0.0	196	78.0
A16-08	17/01/02	1919	1942	D	170	2552.0	1	0.4	92	36.1
A15-09	17/01/02	2230	2255	T	174	2656.5	59	22.2	194	73.0
A14-10	18/01/02	0146	0157	N	60	967.2	37	38.3	6	6.2
A13-09	18/01/02	0414	0440	T	174	2736.0	7	2.6	17	6.2
A14-08	18/01/02	0809	0833	D	171	2283.9	15	6.6	25	10.9
A15-07	18/01/02	1145	1208	D	170	2478.7	2	0.8	109	44.0
A16-06	18/01/02	1531	1555	D	169	2309.4	0	0.0	90	39.0
A15-05	18/01/02	1908	1933	D	169	2295.9	0	0.0	284	123.7
A14-06	18/01/02	2238	2301	N	170	2226.0	0	0.0	422	189.6
A13-07	19/01/02	0200	0228	N	170	2719.4	1	0.4	484	178.0
A12-08	19/01/02	0512	0535	D	170	2119.4	39	18.4	1	0.5
A11-07	19/01/02	0836	0900	D	169	2491.6	389	156.1	2	0.8
A11-05	19/01/02	1254	1319	D	170	2479.4	0	0.0	81	32.7
A11-03	19/01/02	1718	1744	D	173	2392.4	0	0.0	290	121.2
A11-01	19/01/02	2131	2153	T	171	2190.4	0	0.0	598	273.0
ELEPHANT ISLAND AREA										
A09-01	20/01/02	0147	0208	N	170	2111.1	0	0.0	2208	1045.9
A09-02	20/01/02	0440	0505	D	169	2351.5	3	1.3	2904	1235.0
A09-03	20/01/02	0734	0758	D	171	2509.1	1	0.4	2526	1006.7
A09-04	20/01/02	1026	1049	D	169	2291.5	9	3.9	177	77.2
A09-05	20/01/02	1321	1348	D	171	2623.1	24	9.1	286	109.0
A09-06	20/01/02	1705	1732	D	170	2759.6	0	0.0	17	6.2
A09-07	20/01/02	2037	2053	D	170	2281.6	39	17.1	0	0.0
A09-08	20/01/02	2321	2342	N	169	2167.3	77	35.5	21	9.7
A08-08	21/01/02	0202	0230	N	170	2992.2	3	1.0	3	1.0
A08-06	21/01/02	0718	0744	D	170	2590.7	3	1.2	14	5.4
A08-04	21/01/02	1306	1332	D	169	2730.9	0	0.0	180	65.9
A08-02	21/01/02	2015	2039	D	171	2241.9	1	0.4	1932	861.8
A07-01	21/01/02	2345	0011	N	170	2420.8	24	9.9	1302	537.8
A07-02	21/01/02	0232	0259	N	174	2825.3	8	2.8	1736	614.5
A07-03	22/01/02	0527	0551	D	170	2358.0	0	0.0	2868	1216.3
A07-04	22/01/02	0829	0851	D	174	2307.9	3	1.3	650	281.6
A07-05	22/01/02	1115	1135	D	171	2241.4	5	2.2	0	0.0
A07-06	22/01/02	1418	1442	D	170	2504.1	51	20.4	0	0.0
A07-07	22/01/02	1723	1749	D	170	2377.7	76	32.0	84	35.3
A07-08	22/01/02	2015	2038	D	170	2341.9	1	0.4	32	13.7
A06-08	22/01/02	2251	2317	N	170	2349.3	0	0.0	1617	688.3
A06-06	23/01/02	0256	0319	N	140	2140.7	20	9.3	18	8.4
A05-04	23/01/02	0750	0815	D	171	2333.6	48	20.6	41	17.6
A05-02	23/01/02	1238	1304	D	170	2509.1	21	8.4	957	381.4
A04-01	23/01/02	1619	1642	D	170	2431.0	5	2.1	27	11.1
A04-02	23/01/02	1904	1926	D	170	2156.0	49	22.7	788	365.5
A04-03	23/01/02	2201	2222	N	170	2141.2	810	378.3	3839	1792.9
A04-04	24/01/02	0052	0120	N	170	2601.3	219	84.2	181	69.6
A04-05	24/01/02	0330	0355	N	170	2523.2	609	241.4	238	94.3
A04-06	24/01/02	0718	0740	D	156	2115.0	14	6.6	80	37.8
A04-07	24/01/02	1843	1905	D	170	2105.6	3	1.4	0	0.0
A04-08	24/01/02	2130	2154	T	170	2311.7	1	0.4	521	225.4

Tab. 4.1 (Contd.)
SURVEY A

STATION #	DATE	TIME START (LOCAL)	TIME END (LOCAL)	DIEL	TOW DEPTH (m)	FLOW VOLUME (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/1000M3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000M3
A03-08	25/01/02	0006	0031	N	170	2500.7				
A03-06	25/01/02	0418	0443	T	170	2446.8	2	0.8	78	31.9
A03-04	25/01/02	0925	0949	D	171	2157.1	1	0.5	81	37.6
A03-02	25/01/02	1359	1426	D	170	2736.8	81	29.6	7	2.6
A02-01	25/01/02	1731	1755	D	170	2370.6	31	13.1	95	40.1
A02-02	25/01/02	2019	2039	D	170	2274.5	26	11.4	168	73.9
A02-03	25/01/02	2254	2318	N	170	2280.6	263	115.3	820	359.6
A02-04	26/01/02	0131	0149	N	170	2149.6	218	101.4	784	364.7
A02-05	26/01/02	0409	0434	T	170	2233.1	1024	458.6	1352	605.4
A02-06	26/01/02	0709	0733	D	169	2219.4	34	15.3	401	180.7
A02-07	26/01/02	0955	1018	D	170	2317.8	84	36.2	1432	617.8
A02-08	26/01/02	1237	1302	D	171	2431.1	45	18.5	6848	2816.8
JOINVILLE ISLAND AREA										
A02-09	26/01/02	1527	1555	D	171	2323.0	0	0.0	2761	1188.6
A02-11	26/01/02	1943	2006	D	170	2024.5	263	129.9	3	1.5
A02-13	26/01/02	2333	2356	N	170	2118.0	30	14.2	12	5.7
A04-13	27/01/02	0321	0348	N	171	2523.4	5	2.0	0	0.0
A04-11	27/01/02	0720	0745	D	171	2337.9	24	10.3	0	0.0
A04-09	27/01/02	1159	1223	D	168	2359.5	0	0.0	637	270.0
A06-09	27/01/02	1617	1642	D	170	2478.9	0	0.0	463	186.8
A06-11	27/01/02	2021	2043	D	170	2060.0	106	51.5	0	0.0
A06-12	27/01/02	2247	2312	T	170	2291.5	1139	497.1	0	0.0
SOUTH AREA										
A07-11	28/01/02	0139	0205	N	171	2452.3	1970	803.3	200	81.6
A08-10	28/01/02	0453	0519	T	170	2456.7	3	1.2	607	247.1
A09-09	28/01/02	0736	0748	D	86	1135.5	0	0.0	0	0.0
A10-10	28/01/02	1042	1104	D	170	1757.0	0	0.0	0	0.0
A09-11	28/01/02	1403	1428	D	170	2703.7	3993	1476.9	59	21.8
A08-12	28/01/02	1656	1720	D	156	2330.6	1068	458.3	3	1.3
A09-13	28/01/02	1950	2004	D	110	1355.3	2	1.5	157	115.8
A10-12	28/01/02	2257	2321	N	170	2332.7	0	0.0	3044	1304.9
A11-11	29/01/02	0225	0249	N	170	2400.0	1	0.4	2724	1135.0
A12-12	29/01/02	0550	0615	D	171	2555.7	3	1.2	375	146.7
A11-13	29/01/02	0858	0920	D	173	2396.3	2	0.8	162	67.6
A12-14	29/01/02	1153	1220	D	166	2830.6	0	0.0	202	71.4
A13-13	29/01/02	1526	1550	D	170	2725.1	10	3.7	204	74.9
A14-12	29/01/02	1836	1858	D	171	2082.2	3	1.4	2	1.0
				SURVEY AREA A						
				N=95			14777		59988	
						AVG		65.5		267.7
						STD		202.3		487.5
						MEDIAN		2.0		69.6
				WEST AREA						
				N=25			2215		5480	
						AVG		42.0		92.8
						STD		141.2		142.6
						MEDIAN		0.8		39.0
				ELEPHANT ISLAND AREA						
				N=44			3938		42542	
						AVG		39.0		409.9
						STD		93.3		614.7
						MEDIAN		7.5		85.8
				JOINVILLE ISLAND AREA						
				N=9			1567		3876	
						AVG		78.3		183.6
						STD		153.4		367.7
						MEDIAN		10.3		1.5
				SOUTH AREA						
				N=17			7057		8090	
						AVG		161.7		201.2
						STD		390.5		378.1
						MEDIAN		0.8		71.4

Table 4.1 (Contd.)
B. SURVEY D

STATION #	DATE	TIME START (LOCAL)	TIME END (LOCAL)	DIEL	TOW DEPTH (m)	FLOW VOLUME (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/1000M3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000M3
SOUTH AREA										
D15-15	24/02/02	0204	0230	N	171	2861.9	21654	7566.4	198	69.2
D16-14	24/02/02	0506	0530	N	171	2543.8	69	27.1	0	0.0
D17-13	24/02/02	0759	0824	D	170	2505.6	2	0.8	0	0.0
WEST AREA										
D18-12	24/02/02	1104	1128	D	170	2513.4	0	0.0	2	0.8
D19-11	24/02/02	1422	1446	D	170	2392.4	2	0.8	0	0.0
D20-10	24/02/02	1814	1839	D	170	2427.3	0	0.0	1710	704.5
D18-10	25/02/02	0253	0324	N	170	3199.4	4	1.3	76	23.8
D17-11	25/02/02	0610	0627	D	120	1586.4	6	3.8	0	0.0
D16-10	25/02/02	0947	1010	D	170	2328.6	0	0.0	0	0.0
D17-09	25/02/02	1336	1402	D	172	2685.0	0	0.0	3	1.1
D18-08	25/02/02	1704	1731	D	171	2661.7	0	0.0	77	28.9
D17-07	25/02/02	2045	2045	T	169	2359.0	0	0.0	8964	3800.0
D16-08	26/02/02	0008	0037	N	170	2884.6	2	0.7	430	149.1
D15-09	26/02/02	0325	0351	N	169	2774.2	28	10.1	270	97.3
D14-10	26/02/02	0617	0631	D	81	1460.4	10695	7323.1	0	0.0
D13-09	26/02/02	0929	0952	D	165	2221.3	20700	9318.7	0	0.0
D14-08	26/02/02	1307	1332	D	170	2451.7	4	1.6	14	5.7
D15-07	26/02/02	1657	1721	D	171	2294.7	0	0.0	7	3.1
D16-06	26/02/02	2022	2045	T	170	2171.8	0	0.0	3328	1532.4
D15-05	26/02/02	2357	0025	N	170	2671.6	0	0.0	18292	6846.7
D14-06	27/02/02	0331	0400	N	171	2576.1	1	0.4	3961	1537.6
D13-07	27/02/02	0731	0758	D	170	2443.2	0	0.0	19	7.8
D12-08	27/02/02	1042	1105	D	171	1970.7	0	0.0	49	24.9
D11-07	27/02/02	1404	1432	D	171	3277.4	11	3.4	0	0.0
D11-05	27/02/02	1859	1927	D	171	2582.6	0	0.0	2395	927.4
D11-03	27/02/02	2325	2348	N	170	2259.3	0	0.0	19782	8755.8
D11-01	28/02/02	0325	0349	N	170	2156.8	1	0.5	10260	4757.0
ELEPHANT ISLAND AREA										
D09-01	28/02/02	0750	0813	D	170	2154.5	0	0.0	5650	2622.4
D09-02	28/02/02	1030	1053	D	170	1954.3	0	0.0	689	352.6
D09-03	28/02/02	1313	1337	D	170	2448.1	0	0.0	4705	1921.9
D09-04	28/02/02	1548	1613	D	170	2382.0	0	0.0	1050	440.8
D09-05	28/02/02	1819	1843	D	171	2334.1	0	0.0	30	12.9
D09-06	28/02/02	2055	2119	T	169	2215.0	72	32.5	410	185.1
D09-07	28/02/02	2336	2349	N	170	2358.6	3	1.3	675	286.2
D09-08	01/03/02	0148	0210	N	170	2414.4	1	0.4	170	70.4
D08-08	01/03/02	0413	0441	N	170	2580.9	15	5.8	452	175.1
D08-06	01/03/02	0835	0859	D	170	2084.0	7	3.4	6	2.9
D08-04	01/03/02	1241	1306	D	170	2412.7	0	0.0	1536	636.6
D08-02	01/03/02	1640	1707	D	170	2475.2	0	0.0	740	299.0
D07-01	01/03/02	1948	2010	T	170	1824.4	0	0.0	5260	2883.1
D07-02	01/03/02	2232	2257	N	170	2253.7	4	1.8	6544	2903.7
D07-03	02/03/02	0116	0141	N	169	2850.8	3	1.1	2916	1022.9
D07-04	02/03/02	0414	0444	N	170	2839.1	2	0.7	5540	1951.3
D07-05	02/03/02	0710	0735	D	170	2154.7	1	0.5	122	56.6
D07-06	02/03/02	0949	1006	D	170	2194.8	2	0.9	0	0.0
D07-07	02/03/02	1212	1237	D	170	2486.8	0	0.0	5	2.0
D07-08	02/03/02	1454	1519	D	171	2346.0	0	0.0	0	0.0
D06-08	02/03/02	1733	1759	D	170	2402.2	0	0.0	0	0.0
D06-06	02/03/02	2121	2140	N	140	1536.2	113	73.6	1	0.7
D05-04	03/03/02	0153	0214	N	169	2019.4	0	0.0	1415	700.7
D05-02	03/03/02	0600	0626	T	170	2567.2	0	0.0	1235	481.1
D04-01	03/03/02	0919	0942	D	170	2095.9	0	0.0	1398	667.0
D04-02	03/03/02	1214	1236	D	170	2141.0	0	0.0	745	348.0
D04-03	03/03/02	1501	1524	D	170	2274.5	3	1.3	40	17.6
D04-04	03/03/02	1740	1815	D	171	2512.8	0	0.0	14	5.6
D04-05	03/03/02	2030	2052	N	170	2059.8	231	112.1	3094	1502.1
D04-06	04/03/02	0124	0146	N	149	2229.4	194	87.0	132	59.2
D04-07	04/03/02	0524	0550	T	170	2232.1	4	1.8	833	373.2
D04-08	04/03/02	0814	0837	D	170	2285.1	0	0.0	62	27.1
D03-08	04/03/02	1045	1108	D	170	2125.1	0	0.0	458	215.5

Table 4.1 (Contd.)
SURVEY D

STATION #	DATE	TIME START (LOCAL)	TIME END (LOCAL)	DIEL	TOW DEPTH (m)	FLOW VOLUME (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/1000M3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000M3
D03-06	04/03/02	1444	1507	D	170	2395.0	4	1.7	0	0.0
D03-04	04/03/02	1905	1931	D	170	2312.9	1	0.4	69	29.8
D03-02	04/03/02	2358	0021	N	170	2323.9	6	2.6	1141	491.0
D02-01	05/03/02	0345	0410	N	171	2244.1	9	4.0	2707	1206.3
D02-02	05/03/02	0648	0714	D	170	2436.8	0	0.0	493	202.3
D02-03	05/03/02	1003	1026	D	171	2047.1	0	0.0	158	77.2
D02-04	05/03/02	1315	1341	D	171	2571.2	195	75.8	153	59.5
D02-05	05/03/02	1611	1633	D	174	1784.0	1	0.6	524	293.7
D02-06	05/03/02	1909	1943	T	170	2095.9	19	9.1	1535	732.4
D02-07	05/03/02	2201	2226	N	170	2325.9	1	0.4	1012	435.1
D02-08	06/03/02	0020	0047	N	170	2576.5	17	6.6	3465	1344.8
JOINVILLE ISLAND AREA										
D02-09	06/03/02	0251	0313	N	171	2302.3	21	9.1	816	354.4
D02-11	06/03/02	0659	0724	D	170	2294.9	4	1.7	2	0.9
D02-13	06/03/02	1054	1120	D	170	2465.8	9	3.6	2	0.8
D04-13	06/03/02	1444	1508	D	170	2600.3	2	0.8	28	10.8
D04-11	06/03/02	1830	1854	D	170	2272.3	0	0.0	0	0.0
D04-09	06/03/02	2232	2256	N	169	2201.4	39	17.7	1193	541.9
D06-09	07/03/02	0245	0312	N	171	2402.2	9	3.7	1346	560.3
D06-11	07/03/02	0657	0723	D	170	2419.3	1	0.4	5	2.1
D06-12	07/03/02	0927	0952	D	170	2250.7	3	1.3	0	0.0
SOUTH AREA										
D07-11	07/03/02	1220	1245	D	170	2427.5	0	0.0	48	19.8
D08-10	07/03/02	1532	1555	D	170	2229.4	1	0.4	1	0.4
D09-09	07/03/02	1756	1808	D	75	1076.7	0	0.0	0	0.0
D10-10	07/03/02	2101	2123	N	170	1920.0	16	8.3	194	101.0
D09-11	08/03/02	0016	0039	N	170	2333.4	15	6.4	127	54.4
D08-12	08/03/02	0327	0348	N	161	2223.8	643	289.1	0	0.0
D09-13	08/03/02	0631	0648	D	115	1577.7	335	212.3	336	213.0
D10-12	08/03/02	0936	1002	D	170	2472.1	5	2.0	0	0.0
D11-11	08/03/02	1247	1314	D	171	2675.3	0	0.0	0	0.0
D12-12	08/03/02	1606	1632	D	170	2424.2	0	0.0	23	9.5
D11-13	08/03/02	1911	1937	D	170	2447.0	0	0.0	20	8.2
D12-14	08/03/02	2209	2227	N	120	1722.8	1136	659.4	56	32.5
D13-13	09/03/02	0145	0211	N	170	2622.2	1400	533.9	5650	2154.6
D14-12	09/03/02	0458	0527	N	170	2764.2	36	13.0	4	1.4
					SURVEY AREA D					
					N=94		57762		136872	
						AVG		281.4		621.6
						STD		1426.0		1372.5
						MEDIAN		0.5		59.4
					WEST AREA					
					N=24		31454		69639	
						AVG		694.3		1216.8
						STD		2317.5		2337.9
						MEDIAN		0.0		24.3
					ELEPHANT ISLAND AREA					
					N=44		908		57184	
						AVG		9.7		570.3
						STD		25.4		782.3
						MEDIAN		0.4		290.0
					JOINVILLE ISLAND AREA					
					N=9		88		3392	
						AVG		4.3		163.5
						STD		5.4		234.0
						MEDIAN		1.7		2.1
					SOUTH AREA					
					N=17		25312		6657	
						AVG		548.2		156.7
						STD		1765.5		502.3
						MEDIAN		6.4		8.2

Table 4.2 Maturity stage composition of krill collected in the large survey area and four subareas during January-March 2002. Advanced maturity stages are proportions of mature females that are 3c-3e in January and 3d-3e in February-March.

	E. superba January 2002				
Area	Survey A	West	Elephant I.	Joinville I.	South
Stage	%	%	%	%	%
Juveniles	72.5	57.3	46.3	92.5	88.2
Immature	10.9	16.7	9.0	6.0	11.8
Mature	16.6	26.0	44.7	1.5	0.0
Females:					
F2	2.2	4.5	0.4	1.9	2.7
F3a	0.5	2.4	0.5	0.1	0.0
F3b	0.8	0.9	2.3	0.0	0.0
F3c	4.2	1.9	13.7	0.0	0.0
F3d	4.9	14.8	10.0	0.7	0.0
F3e	1.8	0.0	6.2	0.0	0.0
Advanced Stages	89.8	83.5	91.6	87.4	0.0
Males:					
M2a	6.1	8.3	3.0	3.6	8.0
M2b	2.0	3.1	4.0	0.5	0.7
M2c	0.7	0.8	1.5	0.1	0.4
M3a	0.5	0.2	1.7	0.2	0.0
M3b	3.9	5.8	10.4	0.5	0.0
Male:Female	0.9	0.8	0.6	1.8	3.3
No. measured	2629	559	1437	319	314

	February-March 2002				
Area	Survey D	West	Elephant I.	Joinville I.	South
Stage	%	%	%	%	%
Juveniles	73.3	71.8	38.9	46.0	76.9
Immature	25.2	27.1	17.3	27.7	23.0
Mature	1.5	1.1	43.8	26.3	0.1
Females:					
F2	5.4	5.1	3.3	2.2	5.8
F3a	0.2	0.3	0.9	1.1	0.0
F3b	0.0	0.0	0.2	1.1	0.0
F3c	0.1	0.0	2.2	0.0	0.1
F3d	0.3	0.0	14.7	16.1	0.1
F3e	0.5	0.7	3.6	5.5	0.0
Advanced Stages	77.5	73.8	85.2	90.5	55.0
Males:					
M2a	11.9	12.4	8.8	17.4	11.2
M2b	6.7	8.2	3.6	5.8	4.9
M2c	1.2	1.4	1.6	2.3	1.1
M3a	0.0	0.0	0.3	1.2	0.0
M3b	0.4	0.0	22.1	1.2	0.0
Male:Female	3.1	3.6	1.5	1.1	2.9
No. measured	1542	268	558	88	628

Table 4.3. Composition and abundance of zooplankton assemblages sampled in large Survey A and D areas, January-March, 2002. F(%) is frequency of occurrence in samples. R is rank and % is percent of total mean abundance represented by each taxon. L and J denote larval and juvenile stages.

	SURVEY A AREA (N=95)						SURVEY D AREA (N=94)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Copepods	100.0	1	67.6	7536.2	14950.1	2305.5	100.0	1	58.3	15904.8	24429.7	6742.7
Calanoides acutus	98.9		34.4	3838.7	8043.7	1001.0	100.0		27.1	7375.0	11497.5	2771.0
Calanus propinquus	100.0		20.6	2299.7	4956.3	551.7	100.0		15.9	4322.9	8751.9	1341.4
Metridia gerlachei	83.2		6.1	682.1	1891.8	140.8	94.7		9.5	2588.0	3380.3	1172.5
Rhincalanus gigas	60.0		2.4	266.1	684.4	14.8	84.0		4.6	1258.7	2870.1	144.7
Other copepods	60.0		2.1	238.5	715.5	20.9	24.5		0.4	110.4	334.4	0.0
Pareuchaeta antarctica	83.2		1.6	183.3	344.5	60.6	70.2		0.6	153.9	233.6	49.1
Copepodites	10.5		0.2	18.3	107.9	0.0	11.7		0.1	24.9	102.1	0.0
Pleuromama robusta	8.4		0.1	7.1	47.9	0.0	12.8		0.2	61.1	262.5	0.0
Pareuchaeta simillus	1.1		0.0	1.9	18.2	0.0	0.0		0.0	0.0	0.0	0.0
Eucalanus sp.	1.1		0.0	0.4	3.5	0.0	0.0		0.0	0.0	0.0	0.0
Haloptilus ocellatus	0.0		0.0	0.0	0.0	0.0	4.3		0.0	10.0	53.9	0.0
Thysanoessa macrura (L)	90.5	2	12.8	1428.1	2673.5	190.1	96.8	3	4.1	1111.5	2230.0	202.8
Radiolarians	42.1	3	9.2	1030.2	4958.2	0.0	36.2	2	29.0	7918.3	26891.7	0.0
Salpa thompsoni	88.4	4	2.4	267.7	487.5	69.6	80.9	5	2.3	621.6	1372.5	59.4
Thysanoessa macrura	92.6	5	2.0	222.6	714.9	39.3	79.8	7	0.4	112.8	251.6	10.8
Chaetognaths	81.1	6	1.5	170.9	327.9	63.2	97.9	4	3.2	880.1	1165.3	337.0
Ostracods	28.4	7	1.0	111.0	926.9	0.0	22.3	12	0.2	42.6	114.6	0.0
Euphausia spp. (L)	11.6	8	0.8	93.5	815.4	0.0	3.2		0.0	4.4	33.9	0.0
Euphausia superba	74.7	9	0.6	65.5	202.3	2.0	57.4	6	1.0	281.6	1426.0	0.5
Clio pyramidata sulcata	75.8	10	0.5	53.4	111.2	6.5	5.3		0.0	0.2	0.9	0.0
Themisto gaudichaudii	86.3	11	0.3	32.5	53.5	13.7	97.9	13	0.1	30.2	41.1	16.9
Euphausia frigida	42.1	12	0.2	20.5	61.1	0.0	66.0	8	0.3	80.0	302.6	6.1
Euphausia superba (L)	28.4	13	0.2	19.4	48.6	0.0	28.7	10	0.2	61.0	220.4	0.0
Euphausia crystallophorias	12.6	14	0.1	16.5	114.0	0.0	11.7	9	0.2	65.3	473.9	0.0
Decapods	9.5	15	0.1	14.0	127.9	0.0	0.0		0.0	0.0	0.0	0.0
Unid. Eggs	2.1		0.1	10.1	94.8	0.0	0.0		0.0	0.0	0.0	0.0
Polychaetes	15.8		0.1	6.7	30.0	0.0	1.1		0.0	0.0	0.1	0.0
Primno macropa	52.6		0.1	6.3	15.5	0.4	57.4	14	0.1	28.2	93.8	0.9
Vibilia antarctica	66.3		0.0	3.9	8.0	0.9	46.8	15	0.1	22.2	92.4	0.0
Lepidonotothen larseni (L)	18.9		0.0	3.8	20.2	0.0	11.7		0.0	1.8	15.2	0.0
Larval Fish (unid.)	8.4		0.0	3.3	23.7	0.0	1.1		0.0	0.0	0.0	0.0
Cyllopus magellanicus	44.2		0.0	3.3	11.7	0.0	34.0		0.0	2.8	10.2	0.0
Tomopteris spp.	46.3		0.0	3.0	9.9	0.0	18.1		0.0	1.1	3.6	0.0
Cumaceans	2.1		0.0	2.7	26.2	0.0	1.1		0.0	0.2	0.0	0.0
Clione limacina	40.0		0.0	2.3	7.5	0.0	4.3		0.0	0.1	0.7	0.0
Spongiobranchaea australis	69.5		0.0	1.9	3.0	1.0	47.9		0.0	1.3	3.2	0.0
Decapods (L)	3.2		0.0	1.7	11.2	0.0	0.0		0.0	0.0	0.0	0.0
Acanthophyra pelagica	2.1		0.0	1.5	14.6	0.0	1.1		0.0	0.0	0.2	0.0
Cyllopus lucasii	34.7		0.0	1.4	3.9	0.0	30.9		0.0	3.0	11.6	0.0
Hyperiella dilatata	53.7		0.0	1.3	2.9	0.4	38.3		0.0	2.6	8.1	0.0
Ihlea racovitzai	12.6		0.0	1.1	4.6	0.0	5.3		0.0	0.3	1.6	0.0
Euphausia triacantha	7.4		0.0	0.8	4.1	0.0	22.3		0.0	2.2	5.7	0.0
Crustacean larvae	1.1		0.0	0.8	7.8	0.0	0.0		0.0	0.0	0.0	0.0
Limacina helicina	12.6		0.0	0.8	3.5	0.0	5.3		0.0	0.6	3.7	0.0
Dimophyes arctica	13.7		0.0	0.6	3.6	0.0	8.5		0.0	0.1	0.7	0.0
Hyperiids	4.2		0.0	0.5	4.1	0.0	0.0		0.0	0.0	0.0	0.0
Diphyes antarctica	15.8		0.0	0.4	1.9	0.0	8.5		0.0	0.2	0.9	0.0
Hydromedusae	15.8		0.0	0.4	1.5	0.0	5.3		0.0	0.0	0.2	0.0
Bathylagus sp. (L)	3.2		0.0	0.3	2.6	0.0	0.0		0.0	0.0	0.0	0.0
Lepidonotothen kempi (L)	8.4		0.0	0.3	1.4	0.0	18.1		0.0	0.3	0.8	0.0
Modeeria rotunda?	2.1		0.0	0.2	2.2	0.0	2.1		0.0	0.0	0.2	0.0
Larvaceans	4.2		0.0	0.2	1.4	0.0	2.1		0.0	2.4	23.4	0.0
Amphipod	2.1		0.0	0.2	2.0	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiella spp.	11.6		0.0	0.1	0.5	0.0	12.8		0.0	0.2	0.8	0.0
Notothenops nudifrons (L)	5.3		0.0	0.1	0.7	0.0	2.1		0.0	0.0	0.2	0.0
Mysids	3.2		0.0	0.1	0.9	0.0	2.1		0.0	0.1	1.0	0.0
Trematomus newnesi (L)	4.2		0.0	0.1	0.4	0.0	1.1		0.0	0.0	0.0	0.0
Chromatonema rubra?	2.1		0.0	0.1	0.4	0.0	3.2		0.0	0.3	2.3	0.0
Trematomus lepidorhinus (L)	1.1		0.0	0.1	0.5	0.0	0.0		0.0	0.0	0.0	0.0
Clio pyramidata antarctica?	2.1		0.0	0.0	0.4	0.0	4.3		0.0	0.1	0.5	0.0
Chionodraco rastrospinosus (L)	2.1		0.0	0.0	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Pleurobrachia pileus	2.1		0.0	0.0	0.4	0.0	0.0		0.0	0.0	0.0	0.0

Table 4.3 (Contd.)

TAXON	SURVEY A AREA (N=95)						SURVEY D AREA (N=94)					
	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Prionodraco evansii (J)	4.2		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Electrona carlsbergi	2.1		0.0	0.0	0.3	0.0	1.1		0.0	0.0	0.1	0.0
Pelagobia longicirrata	1.1		0.0	0.0	0.3	0.0	1.1		0.0	0.0	0.0	0.0
Schyphomedusae	2.1		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Cyllopus spp.	3.2		0.0	0.0	0.2	0.0	13.8		0.0	0.9	3.5	0.0
Electrona antarctica	3.2		0.0	0.0	0.2	0.0	12.8		0.0	0.1	0.5	0.0
Trematomus scotti (L)	1.1		0.0	0.0	0.3	0.0	4.3		0.0	0.0	0.2	0.0
Hyperiella macronyx	3.2		0.0	0.0	0.2	0.0	1.1		0.0	0.0	0.0	0.0
Electrona spp. (L)	3.2		0.0	0.0	0.2	0.0	20.2		0.0	2.2	17.0	0.0
Isopods	3.2		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Gastropods	2.1		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Vanadis antarctica	2.1		0.0	0.0	0.2	0.0	2.1		0.0	0.0	0.1	0.0
Calycopsis borchgrevinki	1.1		0.0	0.0	0.2	0.0	4.3		0.0	0.0	0.2	0.0
Orchomene plebs	1.1		0.0	0.0	0.2	0.0	2.1		0.0	0.0	0.2	0.0
Hyperiella antarctica	1.1		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Notolepis coatsi (L)	4.2		0.0	0.0	0.1	0.0	12.8		0.0	0.2	0.9	0.0
Sipunculids	3.2		0.0	0.0	0.1	0.0	4.3		0.0	1.5	9.1	0.0
Hyperia antarctica	1.1		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Clione antarctica	1.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Lepidonotothen larseni (J)	1.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Siphonophora	2.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Ctenophora	1.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Staurophora mertensi ?	1.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Pleuragramma antarcticum (L)	1.1		0.0	0.0	0.1	0.0	5.3		0.0	0.2	1.0	0.0
Beroe cucumis	2.1		0.0	0.0	0.1	0.0	1.1		0.0	0.0	0.0	0.0
Notothenia spp. (L)	2.1		0.0	0.0	0.1	0.0	1.1		0.0	0.0	0.0	0.0
Gobionotothen gibberifrons (L)	1.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Zanclonia weldoni?	2.1		0.0	0.0	0.1	0.0	6.4		0.0	0.0	0.2	0.0
Gammarids	1.1		0.0	0.0	0.1	0.0	4.3		0.0	2.3	21.9	0.0
Hyperoche medusarum	1.1		0.0	0.0	0.1	0.0	3.2		0.0	0.0	0.1	0.0
Artededraco mirus (L)	1.1		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Pegantha martgon	1.1		0.0	0.0	0.0	0.0	3.2		0.0	0.1	0.7	0.0
Bolinopsis infundibulus	1.1		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Eusirus antarcticus	1.1		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.4	0.0
Schizobrachium polycotylum?	1.1		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Krefftichthys anderssoni (L)	1.1		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Parachaenechthys charcoti (L)	1.1		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.1	0.0
Gymnoscopelus braueri	1.1		0.0	0.0	0.0	0.0	6.4		0.0	0.1	0.3	0.0
Gymnoscopelus nicholsi	1.1		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.1	0.0
Electrona subaspera	1.1		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Spongiobranchaea sp.	1.1		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Pasiaphaea sp. larvae	1.1		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Euphausia frigida (L)	---		---	---	---	---	19.1	11	0.2	53.4	203.1	0.0
E. crystallorophorias (L)	---		---	---	---	---	6.4		0.1	14.1	100.4	0.0
Euphausia triacantha (L)	---		---	---	---	---	1.1		0.0	0.8	8.1	0.0
Limacina spp.	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.2	2.2	0.0
Arctapodema ampla	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.1	0.8	0.0
Clytia sp.?	0.0		0.0	0.0	0.0	0.0	4.3		0.0	0.1	0.3	0.0
Cyphocaris richardi	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.3	0.0
Champsocephalus gunnari (L)	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.2	0.0
Harpagifer antarcticus (L)	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.2	0.0
Gerlache australis (L)	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.1	0.0
Atolla wyvillei	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.1	0.0
Cephalopods	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.1	0.0
Bolinopsis spp.	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.1	0.0
Trematomus centronotus (L)	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.1	0.0
Scina spp.	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.1	0.0
Pyrasoma atlanticum	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.0	0.0
Orchomene rossi	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.0	0.0
Mitrocomella brownei?	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.0	0.0
Bathydraco antarcticus (L)	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.0	0.0
Periphylla periphylla	0.0		0.0	0.0	0.0	0.0	1.1		0.0	0.0	0.0	0.0
TOTAL				11143.1	20915.5	3775.6				27261.0	47141.2	16157.8
TAXA	103			19.4	3.8	20	93			17.5	3.6	18

Table 4.4. Composition and abundance of zooplankton assemblages sampled in four subareas, January-March 2002 (Surveys A & D). F(%) is frequency of occurrence in samples. R is rank and % is percent of total mean abundance represented by each taxon. L and J denote larval and juvenile stages. Euphausia sp. larvae in Joinville Island area may be E. superba.

A. Survey A	WEST AREA (N=25)						ELEPHANT ISLAND AREA (N=44)						JOINVILLE ISLAND AREA (N=9)						SOUTH AREA (N=17)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Copepods	100.0	1	66.7	16970.4	18426.5	12488.0	100.0	1	73.5	5484.3	14585.6	2174.9	100.0	1	37.1	1556.3	1609.0	1288.3	100.0	1	64.8	2138.9	2801.1	895.0
Calanoides acutus	100.0		33.9	8619.4	9452.8	5643.6	97.7		39.3	2931.3	8293.0	876.4	100.0		17.3	725.1	611.0	661.8	100.0		24.4	805.3	1373.2	129.3
Calanus propinquus	100.0		19.1	4862.7	5064.8	3385.9	100.0		25.0	1862.2	5659.2	502.7	100.0		7.6	318.4	251.7	184.0	100.0		21.6	712.2	1368.2	124.8
Metridia gerlachei	92.0		6.3	1606.0	3399.6	326.4	77.3		4.7	350.8	467.6	130.3	100.0		9.7	407.1	808.5	38.0	76.5		9.9	326.5	620.5	48.1
Rhincalanus gigas	76.0		2.7	685.6	1100.9	88.8	63.6		1.9	141.6	381.0	16.4	22.2		0.6	23.9	65.3	0.0	47.1		3.0	99.5	316.0	0.0
Other copepods	92.0		3.0	769.8	1236.8	380.8	54.5		0.6	44.2	89.0	11.0	22.2		0.1	4.5	8.7	0.0	47.1		2.5	84.1	159.5	0.0
Pareuchaeta antarctica	88.0		1.6	412.0	556.9	232.1	84.1		1.6	122.7	185.6	57.7	77.8		1.8	73.9	84.0	28.5	76.5		1.9	62.1	82.2	17.0
Copepodites	8.0		0.0	9.8	39.3	0.0	11.4		0.4	30.1	154.1	0.0	0.0		0.0	0.0	0.0	0.0	17.6		0.3	9.9	24.7	0.0
Pleuromama robusta	4.0		0.0	3.8	18.4	0.0	6.8		0.0	1.4	6.3	0.0	11.1		0.1	3.4	9.7	0.0	17.6		0.9	28.7	107.7	0.0
Pareuchaeta simillus	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.3	10.5	41.9	0.0
Eucalanus sp.	4.0		0.0	1.4	6.7	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Thysanoessa macrura (L)	100.0	2	15.6	3973.5	3831.6	3082.3	97.7	2	10.4	773.3	1379.1	181.7	100.0		2.0	85.4	80.2	57.3	52.9		2.7	90.7	216.5	1.6
Radiolarians	48.0	3	13.8	3523.1	9054.8	0.0	45.5	4	2.9	216.5	1298.4	0.0	44.4		0.2	6.4	11.1	0.0	23.5		0.4	12.4	43.4	0.0
Salpa thompsoni	96.0	7	0.4	92.8	142.7	39.0	90.9	3	5.5	410.0	614.6	85.8	55.6	4	4.4	183.6	367.7	1.5	88.2	3	6.1	201.2	378.1	71.4
Thysanoessa macrura	80.0	5	1.0	252.8	853.1	19.6	97.7	5	2.7	200.9	784.8	33.1	88.9		0.9	39.2	55.8	5.6	100.0	2	10.0	331.3	397.7	176.5
Chaetognaths	84.0	4	1.3	324.8	521.7	156.3	81.8	6	1.9	139.8	221.1	76.6	66.7		0.6	25.5	50.0	6.9	82.4	5	3.1	102.1	139.6	47.2
Ostracods	16.0	10	0.1	19.5	64.9	0.0	18.2		0.1	6.9	22.4	0.0	55.6	2	24.2	1013.3	2852.5	0.4	58.8		1.1	37.4	95.8	7.0
Euphausia spp. (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	100.0	3	23.5	984.6	2478.1	68.9	11.8		0.0	1.1	3.0	0.0
Euphausia superba	60.0	9	0.2	42.0	141.2	0.4	88.6	7	0.5	39.0	93.3	7.5	66.7		1.9	78.3	153.4	10.3	64.7	4	4.9	161.7	390.5	0.8
Clio pyramidata sulcata	92.0	6	0.5	134.4	166.5	60.0	84.1	9	0.4	33.1	73.0	6.5	55.6		0.1	2.5	3.6	1.0	41.2		0.4	13.8	28.9	0.0
Themisto gaudichaudii	100.0	8	0.3	77.4	79.0	48.7	100.0		0.3	23.1	30.5	12.3	22.2		0.1	2.7	6.4	0.0	64.7		0.2	6.5	9.0	1.8
Euphausia frigida	44.0		0.0	6.9	11.4	0.0	50.0	10	0.4	28.0	56.1	0.4	0.0		0.0	0.0	0.0	0.0	41.2		1.0	31.9	108.5	0.0
Euphausia superba (L)	4.0		0.0	1.5	7.6	0.0	47.7	8	0.5	35.8	64.6	0.0	---		---	---	---	---	29.4		0.4	13.4	30.3	0.0
Euphausia crystallorophorias	4.0		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	33.3		0.1	2.8	5.1	0.0	47.1		2.7	90.4	256.9	0.0
Decapods	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	66.7	5	3.4	140.9	393.0	0.5	17.6		0.1	3.4	12.6	0.0
Eggs (unid.)	0.0		0.0	0.0	0.0	0.0	2.3		0.3	21.1	138.4	0.0	11.1		0.1	3.8	10.7	0.0	0.0		0.0	0.0	0.0	0.0
Polychaetes	4.0		0.0	0.2	0.9	0.0	6.8		0.1	8.1	40.5	0.0	66.7		0.2	9.7	17.7	0.5	29.4		0.3	10.7	22.9	0.0
Primno macropa	32.0		0.0	1.9	6.7	0.0	61.4		0.1	9.1	19.6	0.9	33.3		0.0	0.6	1.0	0.0	70.6		0.3	8.8	14.6	2.6
Vibilia antarctica	52.0		0.0	1.2	1.7	0.4	72.7		0.1	4.6	9.1	1.6	66.7		0.2	9.4	13.6	2.5	70.6		0.1	2.8	3.5	1.3
Lepidonotothen larseni (L)	12.0		0.0	0.4	1.9	0.0	6.8		0.0	1.2	7.7	0.0	44.4		0.1	3.6	6.0	0.0	47.1		0.5	15.6	44.0	0.0
Larval Fish (unid.)	8.0		0.0	12.3	44.9	0.0	9.1		0.0	0.1	0.4	0.0	11.1		0.0	0.2	0.5	0.0	5.9		0.0	0.1	0.2	0.0
Cyllopus magellanicus	40.0		0.0	0.6	1.1	0.0	56.8		0.1	6.6	16.6	0.4	11.1		0.0	0.3	0.8	0.0	35.3		0.0	0.2	0.3	0.0
Tomopteris spp.	64.0		0.0	2.4	3.4	1.3	50.0		0.0	2.1	4.3	0.2	33.3		0.1	5.2	9.7	0.0	17.6		0.2	5.2	20.5	0.0
Cumaceans	4.0		0.0	0.0	0.2	0.0	2.3		0.1	5.8	38.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Clione limacina	52.0		0.0	4.3	9.2	0.8	34.1		0.0	2.2	8.2	0.0	55.6		0.0	0.4	0.5	0.4	29.4		0.0	0.5	1.1	0.0
Spongiobranchaea australis	88.0		0.0	3.8	4.7	1.8	63.6		0.0	1.4	1.9	0.5	66.7		0.0	1.0	0.9	0.9	58.8		0.0	1.0	1.1	0.5
Decapods (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.3	11.5	32.5	0.0	11.8		0.1	3.2	9.1	0.0
Acanthophyra pelagica	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.3	8.4	33.7	0.0
Cyllopus lucasii	44.0		0.0	2.4	5.0	0.0	43.2		0.0	1.5	4.2	0.0	11.1		0.0	0.3	0.7	0.0	11.8		0.0	0.3	1.0	0.0
Hyperiella dilatata	60.0		0.0	0.8	0.9	0.7	45.5		0.0	1.1	2.4	0.0	44.4		0.0	1.5	3.6	0.0	70.6		0.1	2.4	4.5	1.1
Ihlea racovitzai	4.0		0.0	0.1	0.3	0.0	15.9		0.0	1.5	5.5	0.0	44.4		0.1	4.4	7.2	0.0	0.0		0.0	0.0	0.0	0.0
Euphausia triacantha	4.0		0.0	0.1	0.3	0.0	13.6		0.0	1.8	5.9	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Crustacean larvae	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.2	8.5	24.1	0.0	0.0		0.0	0.0	0.0	0.0
Limacina helicina	12.0		0.0	0.5	1.6	0.0	4.5		0.0	0.3	2.0	0.0	33.3		0.0	1.1	1.8	0.0	23.5		0.1	2.3	7.1	0.0
Dimophyes arctica	4.0		0.0	1.4	6.8	0.0	11.4		0.0	0.2	0.6	0.0	44.4		0.0	0.9	1.5	0.0	17.6		0.0	0.2	0.4	0.0
Hyperiids	8.0		0.0	0.1	0.2	0.0	2.3		0.0	0.9	5.8	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.7	2.7	0.0
Diphyes antarctica	0.0		0.0	0.0	0.0	0.0	18.2		0.0	0.3	0.6	0.0	33.3		0.0	0.5	0.7	0.0	23.5		0.0	1.3	4.3	0.0
Hydromedusae	20.0		0.0	0.2	0.6	0.0	15.9		0.0	0.3	0.8	0.0	33.3		0.0	2.0	3.9	0.0	0.0		0.0	0.0	0.0	0.0
Bathylagus sp. (L)	4.0		0.0	0.0	0.1	0.0	2.3		0.0	0.6	3.8	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.1	0.2	0.0
Lepidonotothen kempi (L)	4.0		0.0	0.4	1.8	0.0	11.4		0.0	0.3	1.6	0.0	0.0		0.0	0.0	0.0	0.0	11.8		0.0	0.1	0.4	0.0
Modeeria rotunda?	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	22.2		0.1	2.6	6.5	0.0	0.0		0.0	0.0	0.0	0.0
Larvaceans	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.3	0.0	33.3		0.1	2.2	4.1	0.0	0.0		0.0	0.0	0.0	0.0
Amphipod	4.0		0.0	0.8	3.8	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiella spp.	24.0		0.0	0.3	0.7	0.0	6.8		0.0	0.1	0.3	0.0	11.1		0.0	0.0	0.1	0.0	5.9		0.0	0.1	0.6	0.0

Table 4.4 (Contd.)

TAXON	WEST AREA (N=25) F(%)	R	%	MEAN	STD	MEDIAN	ELEPHANT ISLAND AREA (N=44) F(%)	R	%	MEAN	STD	MEDIAN	JOINVILLE ISLAND AREA (N=9) F(%)	R	%	MEAN	STD	MEDIAN	SOUTH AREA (N=17) F(%)	R	%	MEAN	STD	MEDIAN
Notothenops nudifrons (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	33.3		0.0	0.8	1.8	0.0	11.8		0.0	0.3	0.8	0.0
Mysids (unid.)	8.0		0.0	0.4	1.7	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Trematomus newnesi (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.3	0.8	0.0	17.6		0.0	0.2	0.5	0.0
Chromatonema rubra?	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	22.2		0.0	0.6	1.3	0.0	0.0		0.0	0.0	0.0	0.0
Trematomus lepidorhinus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.6	1.6	0.0	0.0		0.0	0.0	0.0	0.0
Clio pyramidata antarctica?	4.0		0.0	0.0	0.2	0.0	2.3		0.0	0.1	0.5	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Chionodraco rastrospinosus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.4	1.2	0.0	5.9		0.0	0.0	0.1	0.0
Pleurobrachia pileus	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.1	0.5	0.0	11.1		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Prionodraco evansii (J)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	44.4		0.0	0.4	0.6	0.0	0.0		0.0	0.0	0.0	0.0
Electrona carlsbergi	4.0		0.0	0.1	0.4	0.0	2.3		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Pelagobia longicirrata	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.1	0.5	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Schyphomedusae	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	11.1		0.0	0.2	0.6	0.0	0.0		0.0	0.0	0.0	0.0
Cyllopus spp.	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.1	0.2	0.0
Electrona antarctica	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Trematomus scotti (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.3	0.8	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiella macronyx	8.0		0.0	0.0	0.1	0.0	2.3		0.0	0.0	0.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Electrona spp. (L)	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.1	0.4	0.0
Isopods (unid.)	4.0		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	22.2		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0
Gastropods (unid.)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	5.9		0.0	0.1	0.4	0.0
Vanadis antarctica	4.0		0.0	0.1	0.3	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Calycopsis borchgrevinki	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Orchomene plebs	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.1	0.4	0.0
Hyperiella antarctica	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Notolepis coatsi (L)	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	11.8		0.0	0.0	0.1	0.0
Sipunculids	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	11.8		0.0	0.1	0.2	0.0
Hyperia antarctica	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.2	0.5	0.0	0.0		0.0	0.0	0.0	0.0
Clione antarctica	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.2	0.5	0.0	0.0		0.0	0.0	0.0	0.0
Lepidonotothen larseni (J)	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Siphonophora	4.0		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.2	0.0
Ctenophora	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.1	0.3	0.0
Staurophora mertensi ?	4.0		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Pleuragramma antarcticum (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0
Beroe cucumis	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.2	0.0	5.9		0.0	0.0	0.1	0.0
Notothenia spp. (L)	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Gobionotothen gibberifrons (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0
Zanclonia weldoni?	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Gammarids	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.2	0.0
Hyperoche medusarum	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.2	0.0
Artededraco mirus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Pegantha martgon	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Bolinopsis infundibulus	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Eusirus antarcticus	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Schizobrachium polycotylum?	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Krefftichthys anderssoni (L)	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Parachaenechthys charcoti (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Gymnoscopelus braueri	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Gymnoscopelus nicholsi	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Electrona subaspera	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Pasiaphaea sp. (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Spongiobranchaea sp.	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
TOTAL				25453.9	29050.3	14577.2				7462.7	17001.6	3551.5				4195.9	6715.7	1746.6				3301.3	2876.0	2313.3
TAXA				18.8	3.6	19				19.2	3.8	20				22.6	3.7	24				19.0	3.3	19

Table 4.4 (Contd.)

B. Survey D	WEST AREA (N=24)						ELEPHANT ISLAND AREA (N=44)						JOINVILLE ISLAND AREA (N=9)						SOUTH AREA (N=17)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Copepods	100.0	1	60.3	24521.9	37120.5	12471.1	100.0	1	54.7	17473.4	20036.9	7563.8	100.0	1	90.5	6448.4	3618.1	6265.5	100.0	1	68.8	4686.1	4924.5	2182.8
Calanoides acutus	100.0		23.2	9419.8	13322.8	5327.0	100.0		29.9	9569.2	12553.1	4585.6	100.0		31.0	2210.5	1767.6	1497.5	100.0		22.6	1543.5	2090.2	344.8
Calanus propinquus	100.0		21.5	8766.1	15259.8	1917.1	100.0		12.0	3827.4	4288.9	2037.2	100.0		10.3	735.0	406.7	656.9	100.0		18.1	1232.0	1487.5	426.9
Rhincalanus gigas	91.7		6.4	2598.6	4683.9	653.1	95.5		3.8	1226.4	1952.7	246.2	22.2		0.2	13.3	26.9	0.0	76.5		1.6	109.8	167.3	47.7
Metridia gerlachei	87.5		7.5	3059.2	3926.1	1956.5	95.5		7.9	2515.1	3124.5	1183.6	100.0		48.3	3438.3	4079.7	1439.5	100.0		24.4	1661.2	2402.8	287.9
Pareuchaeta antarctica	62.5		0.5	185.4	230.7	91.8	68.2		0.5	169.3	269.2	52.5	66.7		0.7	51.3	57.7	31.6	88.2		1.8	124.0	170.1	52.3
Other copepods	29.2		0.5	214.9	454.0	0.0	25.0		0.4	116.0	337.2	0.0	0.0		0.0	0.0	0.0	0.0	29.4		0.1	6.8	12.9	0.0
Copepodites	29.2		0.2	85.8	186.5	0.0	6.8		0.0	5.2	22.5	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	3.0	11.8	0.0
Pleuromama robusta	16.7		0.4	180.2	482.5	0.0	11.4		0.1	30.0	97.2	0.0	0.0		0.0	0.0	0.0	0.0	17.6		0.1	5.8	14.7	0.0
Haloptilus ocellatus	4.2		0.0	11.9	57.1	0.0	6.8		0.0	14.8	66.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Thysanoessa macrura (L)	100.0	3	3.9	1568.8	2229.0	256.2	95.5	3	4.5	1444.9	2665.1	364.0	100.0	3	2.0	141.7	187.6	75.4	94.1		1.7	116.6	102.4	95.3
Themisto gaudichaudii	100.0		0.1	53.7	66.6	22.7	100.0		0.1	24.8	23.5	15.9	77.8		0.1	7.5	8.9	3.5	100.0		0.3	22.9	20.5	18.6
Chaetognaths	95.8	5	2.7	1107.4	1403.6	405.9	100.0	4	3.4	1073.1	1210.4	435.6	100.0	4	1.9	133.1	109.1	98.5	94.1	3	6.7	455.1	532.1	183.6
Salpa thompsoni	75.0	4	3.0	1216.8	2337.9	24.3	90.9	5	1.8	570.4	782.3	250.9	77.8	2	2.3	163.5	234.0	2.1	64.7		2.3	156.7	502.4	8.2
Thysanoessa macrura	66.7	9	0.3	105.0	188.9	25.1	77.3	8	0.2	56.4	132.5	3.5	100.0	5	1.8	127.2	201.3	61.9	94.1	5	3.8	262.4	449.4	95.5
Euphausia frigida	62.5	7	0.4	150.3	529.1	12.3	70.5	7	0.2	78.4	192.3	5.1	88.9		0.3	20.6	21.1	8.9	47.1		0.2	16.2	48.7	0.0
Primno macropa	62.5		0.1	23.1	39.5	2.0	65.9	10	0.1	43.4	131.2	1.8	11.1		0.0	0.0	0.1	0.0	52.9		0.2	10.8	23.4	0.4
Spongiobranchaea australis	58.3		0.0	2.8	5.7	0.4	47.7		0.0	0.9	1.3	0.0	44.4		0.0	0.3	0.4	0.0	35.3		0.0	0.6	1.1	0.0
Euphausia superba	45.8	6	1.7	694.4	2317.5	0.0	54.5		0.0	10.1	25.4	0.4	88.9		0.1	4.3	5.4	1.7	64.7	2	8.0	548.1	1765.6	6.4
Vibilia antarctica	41.7		0.1	20.3	46.5	0.0	61.4		0.1	34.2	129.0	0.6	33.3		0.0	2.7	5.0	0.0	23.5		0.1	4.0	13.5	0.0
Cyllopus lucasii	41.7		0.0	9.5	21.3	0.0	31.8		0.0	1.1	2.7	0.0	22.2		0.0	0.4	0.7	0.0	17.6		0.0	0.3	0.9	0.0
Hyperiella dilatata	41.7		0.0	3.7	7.9	0.0	36.4		0.0	2.8	9.7	0.0	33.3		0.0	2.7	6.4	0.0	41.2		0.0	0.5	1.1	0.0
Radiolarians	33.3	2	26.9	10954.0	27416.2	0.0	54.5	2	34.2	10941.0	32920.3	32.5	11.1		0.0	0.0	0.1	0.0	5.9		0.0	1.3	5.0	0.0
Euphausia triacantha	33.3		0.0	4.9	8.6	0.0	27.3		0.0	1.9	4.6	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.4	1.5	0.0
Cyllopus magellanicus	33.3		0.0	3.8	12.3	0.0	50.0		0.0	3.8	11.6	0.2	11.1		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	0.0
Euphausia superba (L)	29.2	8	0.3	133.7	380.9	0.0	29.5	9	0.2	49.9	140.9	0.0	44.4		0.4	29.2	38.4	0.0	17.6		0.1	4.0	10.9	0.0
Lepidonotothen kempi (L)	29.2		0.0	0.4	1.0	0.0	13.6		0.0	0.2	0.6	0.0	0.0		0.0	0.0	0.0	0.0	23.5		0.0	0.4	0.7	0.0
Notolepis coatsi (L)	25.0		0.0	0.4	1.6	0.0	13.6		0.0	0.2	0.5	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Ostracods	20.8	10	0.2	64.3	136.5	0.0	13.6		0.0	13.4	47.6	0.0	11.1		0.1	9.0	25.6	0.0	52.9		1.5	105.4	180.9	8.3
Electrona spp. (L)	20.8		0.0	0.2	0.6	0.0	25.0		0.0	4.4	24.6	0.0	11.1		0.0	0.2	0.5	0.0	11.8		0.0	0.4	1.1	0.0
Tomopteris spp.	16.7		0.0	1.4	4.8	0.0	25.0		0.0	1.6	3.8	0.0	11.1		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	0.0
Electrona antarctica	12.5		0.0	0.3	0.8	0.0	9.1		0.0	0.1	0.2	0.0	33.3		0.0	0.1	0.2	0.0	11.8		0.0	0.1	0.3	0.0
Cyllopus spp.	8.3		0.0	0.4	1.3	0.0	22.7		0.0	1.6	4.9	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Pegantha margaton	8.3		0.0	0.3	1.3	0.0	2.3		0.0	0.0	0.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Clio pyramidata antarctica	8.3		0.0	0.2	0.8	0.0	4.5		0.0	0.1	0.5	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Gymnoscopelus braueri	8.3		0.0	0.1	0.4	0.0	4.5		0.0	0.0	0.1	0.0	11.1		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	0.0
Diphyes antarctica	8.3		0.0	0.1	0.4	0.0	6.8		0.0	0.3	1.2	0.0	22.2		0.0	0.1	0.2	0.0	5.9		0.0	0.0	0.1	0.0
Euphausia frigida (L)	4.2		0.0	18.3	87.8	0.0	20.5	6	0.3	84.6	278.9	0.0	11.1		0.1	4.3	12.1	0.0	41.2		0.7	48.1	101.3	0.0
E. crystallorophorias (L)	4.2		0.0	14.5	69.6	0.0	4.5		0.1	21.4	136.8	0.0	11.1		0.0	0.0	0.1	0.0	11.8		0.0	1.8	6.2	0.0
Euphausia triacantha (L)	4.2		0.0	3.3	15.8	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Arctapodema ampla	4.2		0.0	0.3	1.6	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiella spp.	4.2		0.0	0.3	1.5	0.0	15.9		0.0	0.1	0.4	0.0	11.1		0.0	0.0	0.1	0.0	17.6		0.0	0.1	0.2	0.0
Limacina helicina	4.2		0.0	0.3	1.5	0.0	2.3		0.0	0.1	0.4	0.0	33.3		0.1	5.1	10.6	0.0	0.0		0.0	0.0	0.0	0.0
Clione limacina	4.2		0.0	0.2	0.7	0.0	2.3		0.0	0.1	0.9	0.0	11.1		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	0.0
Hydromedusae	4.2		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.2	0.5	0.0	17.6		0.0	0.1	0.2	0.0
Electrona carlsbergi	4.2		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Scina spp.	4.2		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Zanclonia weldoni?	4.2		0.0	0.0	0.1	0.0	11.4		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Vanadis antarctica	4.2		0.0	0.0	0.1	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Lepidonotothen larseni (L)	4.2		0.0	0.0	0.1	0.0	2.3		0.0	0.0	0.1	0.0	44.4		0.0	1.0	1.4	0.0	29.4		0.1	9.1	34.8	0.0
Hyperoche medusarum	4.2		0.0	0.0	0.1	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Modeeria rotunda?	4.2		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.2	0.7	0.0	0.0		0.0	0.0	0.0	0.0
Periphylla periphylla	4.2		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0

Table 4.4 (Contd.)

TAXON	WEST AREA (N=24) F(%)	R	%	MEAN	STD	MEDIAN	ELEPHANT ISLAND AREA (N=44) F(%)	R	%	MEAN	STD	MEDIAN	JOINVILLE ISLAND AREA (N=9) F(%)	R	%	MEAN	STD	MEDIAN	SOUTH AREA (N=17) F(%)	R	%	MEAN	STD	MEDIAN
Clio pyramidata sulcata	0.0		0.0	0.0	0.0	0.0	9.1		0.0	0.3	1.3	0.0	11.1		0.0	0.2	0.6	0.0	0.0		0.0	0.0	0.0	0.0
Calycopsis borchgrevinki	0.0		0.0	0.0	0.0	0.0	9.1		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Gammarids	0.0		0.0	0.0	0.0	0.0	6.8		0.0	4.9	31.8	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.1	0.3	0.0
Euphausia spp. (L)	0.0		0.0	0.0	0.0	0.0	6.8		0.0	9.4	49.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Dimophyes arctica	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.1	0.5	0.0	33.3		0.0	0.7	1.7	0.0	17.6		0.0	0.1	0.2	0.0
Orchomene plebs	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Mysids	0.0		0.0	0.0	0.0	0.0	4.5		0.0	0.3	1.5	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Ihlea racovitzai	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.3	2.1	0.0	44.4		0.0	1.4	2.0	0.0	0.0		0.0	0.0	0.0	0.0
Sipunculids	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	22.2		0.2	13.1	25.7	0.0	5.9		0.0	1.3	5.0	0.0
Larvaceans	0.0		0.0	0.0	0.0	0.0	2.3		0.0	5.2	33.9	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Euphausia crystallorophorias	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.3	0.0	0.0		0.0	0.0	0.0	0.0	58.8	4	5.3	360.9	1065.4	14.2
Eusirus antarcticus	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.2	0.8	0.0
Cephalopods	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Champsocephalus gunnari (L)	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiella macronyx	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Acanthophyra pelagica	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Larval Fish	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Beroe cucumis	0.0		0.0	0.0	0.0	0.0	2.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Pleuragramma antarcticum (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	55.6		0.0	1.9	2.6	0.4	0.0		0.0	0.0	0.0	0.0
Trematomus scotti (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	44.4		0.0	0.4	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Clytia ?	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	22.2		0.0	0.4	0.8	0.0	11.8		0.0	0.1	0.4	0.0
Chromatonema rubra?	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	22.2		0.0	2.6	7.0	0.0	5.9		0.0	0.0	0.2	0.0
Leptonotothen nudifrons (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.2	0.6	0.0	5.9		0.0	0.1	0.3	0.0
Gymnoscopelus nicholsi	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.3	0.0	5.9		0.0	0.0	0.1	0.0
Bolinopsis spp.	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	0.0
Harpagifer antarcticus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	5.9		0.0	0.1	0.4	0.0
Pelagobia longicirrata	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Orchomene rossi	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Trematomus newnesi (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Pyrasoma atlanticum	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Atolla wyvillei	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Mitrocomella brownei?	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Bathydraco antarcticus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Cyphocaris richardi	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.8		0.0	0.2	0.6	0.0
Notolepis spp. (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Limacina spp.	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Trematomus centronotus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	1.3	5.0	0.0
Parachaenechthys charcoti (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Polychaetes	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0
Gerlache australis (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.1	0.3	0.0
TOTAL				40679.8	64362.2	27851.0				31959.5	45889.6	19541.7				7123.5	3919.2	12917.7				6816.1	6094.5	4238.1
TAXA				16.8	3.7	18				17.8	3.3	18				18.7	3.4	19				17.2	4.0	17.0

Table 4.5. Larval krill stage composition in (A) Large Survey areas, 1996-2002, and (B) total and individual areas, 2000-2002. Only pooled calyptopis and furcilia stages provided for 1996-1999. Individual stages provided for 2000-2002 surveys. Shaded area denotes stage composition of Euphausia spp. larvae in the A02 Joinville Island area.

(A) Large Survey Area

Stage %	A96	D96	A97	D97	A98	D98	A99	D99	D00	A01	D01	A02	D02
Calyptopis Total	100	86	93	100	68	99	100	97	97	100	98	70	85
Furcilia Total	---	14	7	---	32	1	---	3	3	---	2	30	15

(B) Total, Elephant Island, West, South and Joinville Island Areas

Survey	D00				A01				D01			
Stage %	Total	Eleph	West	South	Total	Eleph	West	South	Total	Eleph	West	South
C1	46.3	46.3	48.8	32.6	24.0	68.4	17.6	95.3	57.1	58.4	37.6	17.8
C2	40.5	40.5	29.3	55.2	66.3	22.1	72.7	---	29.8	29.4	36.1	15.2
C3	9.9	9.8	21.1	12.2	9.7	9.3	9.7	---	11.2	10.7	18.0	67.0
Unid.	0.6	0.6	---	---	---	0.2	---	4.7	---	---	0.8	---
Calyptopis Total	96.9	96.9	99.2	100	100	100	100	100	98.2	98.6	92.5	100
F1	1.4	1.4	0.8	---	---	---	---	---	1.8	1.4	7.4	---
F2	1.2	1.2	---	---	---	---	---	---	---	---	0.1	---
F3	0.1	0.1	---	---	---	---	---	---	---	---	---	---
Unid.	---	---	---	---	---	---	---	---	---	---	---	---
Furcilia Total	2.7	2.7	0.8	---	---	---	---	---	1.8	1.4	7.5	---

Survey	A02					D02				
Stage %	Total	Eleph	West	South	Joinvl	Total	Eleph	West	South	Joinvl
C1	37.3	40.3	50.0	13.9	5.0	18.5	42.2	3.2	50.3	---
C2	15.8	16.3	50.0	7.0	2.9	12.1	4.1	16.7	49.7	15.6
C3	17.4	20.3	---	---	52.5	49.5	23.5	70.0	---	29.5
Unid.	---	---	---	---	---	5.3	---	9.5	---	---
Calyptopis Total	70.5	76.9	100	20.9	60.4	85.5	69.8	99.3	100	45.1
F1	9.6	6.2	---	35	38.2	10.4	22.8	0.7	---	26.8
F2	19.9	17.0	---	44.1	1.4	3.4	7.4	---	---	12.1
F3	---	---	---	---	---	0.7	---	---	---	16.1
Unid.	---	---	---	---	---	---	---	---	---	---
Furcilia Total	29.5	23.1	---	79.1	39.6	14.5	30.2	0.7	---	54.9

Table 4.6. Taxonomic composition of three zooplankton clusters during January 2002 Survey A. R and % are rank and proportion of total mean abundance represented by each taxon.

	CLUSTER 3 (OCEANIC) N=15					CLUSTER 2 (SHELF) N=41					CLUSTER 1 (COASTAL) N=39				
TAXON	R	%	MEAN	STD	MEDIAN	R	%	MEAN	STD	MEDIAN	R	%	MEAN	STD	MEDIAN
Calanoides acutus	1	34.4	14078.6	15314.1	7806.2	1	42.4	3076.9	3800.2	1335.1	1	21.1	701.3	1200.3	241.8
Calanus propinquus	2	21.5	8795.5	9407.1	6538.9	2	25.2	1829.7	2203.6	787.7	5	8.9	295.5	467.9	138.0
Radiolarians	3	15.8	6474.7	10977.1	978.3	15	0.1	9.4	25.5	0.0		0.3	9.4	31.6	0.0
Thysanoessa macrura (L)	4	12.5	5121.7	4255.2	4501.0	3	17.9	1297.1	1813.2	262.4	7	4.4	145.2	282.3	28.1
Metridia gerlachei	5	5.8	2379.8	4170.9	513.2	4	4.0	288.1	500.4	68.6	3	13.4	443.3	659.3	131.2
Rhincalanus gigas	6	2.9	1199.1	1265.8	610.4	7	1.5	106.1	229.3	21.8	11	2.3	75.5	267.4	0.0
Other copepods	7	2.4	983.0	1502.6	380.8	6	1.5	112.1	207.4	25.1	9	2.6	85.1	283.1	0.0
Pareuchaeta antarctica	8	1.6	660.2	616.7	376.1	9	1.4	104.4	163.5	46.2	10	2.5	82.9	103.2	30.1
Chaetognaths	9	1.4	557.5	642.2	372.8	5	1.8	134.0	144.6	103.4	12	1.8	60.9	101.4	15.9
Salpa thompsoni	10	0.7	279.7	376.3	115.3	8	1.4	104.6	267.9	10.9	4	13.1	434.6	626.9	180.7
Clio pyramidata sulcata	11	0.5	213.6	176.6	192.0	11	0.5	39.8	73.2	9.4		0.2	6.0	13.0	1.8
Themisto gaudichaudii	12	0.2	85.6	93.2	45.5	12	0.4	32.3	41.1	15.6	15	0.4	12.3	19.3	4.1
Ostracods	13	0.1	35.1	81.3	0.0		0.1	4.3	20.9	0.0	6	7.6	252.4	1433.8	0.0
Thysanoessa macrura	14	0.0	16.6	37.2	1.6	10	1.0	74.5	117.6	19.6	2	13.8	457.5	1065.6	169.4
Euphausia frigida	15	0.0	9.6	15.2	0.0		0.1	3.8	9.2	0.0	13	1.3	42.3	90.1	1.6
Spongiobranchaea australis		0.0	4.9	3.4	3.4		0.0	1.8	3.4	0.9		0.0	0.9	1.2	0.4
Clione limacina		0.0	4.7	8.4	1.7		0.0	3.4	9.8	0.0		0.0	0.3	0.6	0.0
Tomopteris spp.		0.0	4.7	5.4	2.8		0.0	3.6	13.6	0.0		0.1	1.8	5.2	0.0
Primno macropa		0.0	4.0	11.7	0.0	14	0.1	10.1	21.3	0.5		0.1	3.3	5.4	0.4
Cyllopus magellanicus		0.0	2.6	3.3	1.3		0.0	1.6	5.0	0.0		0.2	5.3	17.2	0.0
Cyllopus lucasii		0.0	1.9	2.4	1.2		0.0	1.3	4.0	0.0		0.0	1.3	4.3	0.0
Vibilia antarctica		0.0	1.8	1.8	1.5		0.0	0.8	1.4	0.0		0.2	7.9	11.2	4.4
Hyperiella dilatata		0.0	1.5	1.0	1.7		0.0	1.2	2.9	0.4		0.0	1.3	3.2	0.0
Euphausia superba		0.0	1.1	2.3	0.0	13	0.2	13.5	25.8	2.6	8	4.4	144.9	297.1	8.4
Limacina helicina		0.0	0.7	2.0	0.0		0.0	1.2	5.1	0.0		0.0	0.4	1.4	0.0
Diphyes antarctica		0.0	0.2	0.5	0.0		0.0	0.1	0.3	0.0		0.0	0.8	2.9	0.0
Ihlea racovitzai		0.0	0.1	0.4	0.0		0.0	0.5	3.2	0.0		0.1	2.2	6.1	0.0
Euphausia crystallophorias		0.0	0.0	0.0	0.0		0.0	0.1	0.5	0.0	14	1.2	39.9	175.3	0.0
Dimophyes arctica		0.0	0.0	0.0	0.0		0.0	0.0	0.1	0.0		0.0	1.3	5.5	0.0
TOTAL			40918.3					7256.2					3315.8		

Table 4.7. Abundance of krill and other dominant zooplankton taxa collected in the Elephant Island area during January-February and February-March surveys, 1992-2002. Zooplankton data are not available for February-March 1992 or January 2000.

Euphausia superba

January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	63	70	63	71	72	71	61	40		60	44
Mean	23.7	28.8	34.5	9.5	82.1	29.6	27.1	5.3	n.a.	18.9	39.0
SD	78.0	64.4	94.2	20.6	245.1	80.5	42.3	8.1	n.a.	32.7	93.3
Med	5.7	8.2	3.1	3.6	11.4	5.6	10.2	1.7	n.a.	6.0	7.5
Max	594.1	438.9	495.9	148.1	1500.6	483.2	175.0	35.1	n.a.	217.7	458.6
February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	67	67	70	71	72	16	61	39	60	57	44
Mean	38.0	35.0	17.1	5.2	133.2	30.4	162.6	35.5	14.4	80.5	10.0
SD	77.4	89.7	63.5	12.0	887.7	56.4	768.3	155.7	35.3	374.0	25.5
Med	7.1	3.0	0.4	1.2	4.1	4.6	4.5	0.8	3.3	4.6	0.4
Max	389.9	542.0	371.1	90.0	7385.4	204.2	5687.0	978.6	253.5	2817.0	112.1

Thysanoessa macrura

January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	63	70	63	71	72	71	61	40		60	44
Mean	48.1	48.8	74.8	104.1	103.4	101.0	135.3	46.6	n.a.	48.2	200.9
SD	57.0	60.1	144.3	231.9	118.1	127.2	150.8	54.1	n.a.	49.2	784.8
Med	22.5	27.5	25.4	36.1	52.3	52.8	98.0	23.2	n.a.	32.2	33.1
Max	233.7	307.1	901.6	1859.0	500.1	616.2	992.3	215.8	n.a.	251.7	5302.0
February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N		67	70	71	72	16	61	39	60	57	44
Mean	n.a.	128.9	77.1	79.7	116.1	181.3	140.6	95.2	35.1	1040.9	56.4
SD	n.a.	235.1	132.6	138.5	147.4	168.0	232.3	131.9	61.5	7262.6	132.5
Med	n.a.	22.1	23.8	22.2	53.6	122.6	70.0	18.0	14.0	44.1	3.5
Max	n.a.	1141.5	815.9	664.9	679.4	538.9	1638.5	589.2	291.6	55381.1	662.7

Salpa thompsoni

January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	63	70	63	71	72	71	61	40		60	44
Mean	94.3	1213.4	931.9	20.2	25.5	223.2	939.7	197.5	n.a.	622.8	410.0
SD	192.3	2536.7	950.2	48.5	36.3	338.4	1556.3	191.6	n.a.	578.4	614.6
Med	14.0	245.8	582.3	1.6	10.5	87.1	348.9	159.1	n.a.	449.3	85.8
Max	1231.1	16078.8	4781.7	239.9	161.8	2006.3	8030.4	873.4	n.a.	3512.4	2816.8
February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	67	67	70	71	72	16	61	39	60	57	44
Mean	n.a.	1585.9	495.1	20.6	33.2	1245.5	977.3	309.1	912.8	452.4	540.6
SD	n.a.	2725.5	579.4	68.5	85.7	1224.6	1496.5	376	3395.1	501.2	771.1
Med	n.a.	605.9	242.6	0.7	5.6	521.0	553.8	160.7	262.9	312.1	250.9
Max	n.a.	16662.5	2377.5	391.9	659.4	4348.3	10712.9	1550.2	24031.9	2416.8	2903.7

Copepods

January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	63	70	63	71	72	71	61	40		60	44
Mean	n.a.	73.5	32.4	741.0	897.5	656.4	41.2	928.2	n.a.	1003.2	5484.3
SD	n.a.	302.7	92.2	1061.3	1726.4	799.1	55.1	1590.8	n.a.	1582.4	14585.6
Med	n.a.	0.0	0.0	346.0	338.2	399.7	21.5	333.0	n.a.	252.2	2174.9
Max	n.a.	2312.6	465.3	7047.5	10598.0	4090.0	276.0	7524.8	n.a.	6909.7	96514.5
February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	67	67	70	71	72	16	61	39	60	57	44
Mean	n.a.	n.a.	3453.3	3707.3	1483.7	1267.8	110.4	1558.4	8019.1	4501.5	17473.4
SD	n.a.	n.a.	8190.8	5750.3	2209.2	1755.6	170.3	2337.5	11824.4	8072.4	20036.9
Med	n.a.	n.a.	172.4	1630.9	970.2	659.8	50.9	621.6	3478.0	1518.0	7563.8
Max	n.a.	n.a.	37987.2	40998.5	16621.0	7289.2	901.1	10786.6	57498.5	39800.7	90224.5

Euphausia superba Larvae

January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	63	70	63	71	72	71	61	40		60	44
Mean	n.a.	n.a.	n.a.	172.1	3.4	19.3	0.4	175.1	n.a.	32.8	35.8
SD	n.a.	n.a.	n.a.	969.4	8.3	27.0	1.6	795.5	n.a.	86.2	64.6
Med	n.a.	n.a.	n.a.	0.0	0.0	6.4	0.0	4.3	n.a.	9.0	0.0
Max	n.a.	n.a.	n.a.	8076.1	42.7	96.5	11.4	5083.2	n.a.	654.0	356.3
February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	67	67	70	71	72	16	61	39	60	57	44
Mean	n.a.	n.a.	n.a.	4593.4	14.1	25.0	2.5	67.2	3423.2	71.9	50.1
SD	n.a.	n.a.	n.a.	20117.0	44.0	81.4	18.3	146.0	8974.1	176.9	140.8
Med	n.a.	n.a.	n.a.	268.6	3.3	0.0	0.0	12.3	248.7	5.1	0.0
Max	n.a.	n.a.	n.a.	167575.6	368.5	339.0	144.1	692.5	44478.2	1197.7	728.6

Thysanoessa macrura Larvae

January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	63	70	63	71	72	71	61	40		60	44
Mean	n.a.	n.a.	n.a.	20.2	372.0	21.5	0.0	116.5	n.a.	269.3	773.3
SD	n.a.	n.a.	n.a.	75.2	858.1	38.4	0.0	348.8	n.a.	608.8	1379.1
Med	n.a.	n.a.	n.a.	0.0	32.1	1.5	0.0	2.8	n.a.	42.7	181.7
Max	n.a.	n.a.	n.a.	441.5	4961.8	159.9	0.0	1519.6	n.a.	3621.0	8984.2
February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	67	67	70	71	72	16	61	39	60	57	44
Mean	n.a.	n.a.	31.7	344.3	511.5	10.8	0.5	185.9	1084.8	613.3	1444.9
SD	n.a.	n.a.	111.1	594.2	1432.5	24.9	2.0	535.7	4147.3	1009.5	2665.1
Med	n.a.	n.a.	0.0	79.9	36.1	1.0	0.0	10.0	26.8	265.3	364.0
Max	n.a.	n.a.	809.1	3735.5	10875.0	104.7	12.1	2990.8	31132.5	5461.9	12270.6

Euphausia frigida

January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	63	70	63	71	72	71	61	40		60	44
Mean	5.4	4.2	4.7	12.1	2.0	9.6	0.3	15.9	n.a.	23.4	28.0
SD	14.9	18.4	14.9	32.1	4.5	21.4	1.4	29.1	n.a.	55.9	56.1
Med	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	n.a.	0.0	0.4
Max		143.0	76.7	175.6	22.5	91.4	10.0	116.0	n.a.	315.6	256.1
February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	67	67	70	71	72	16	61	39	60	57	44
Mean	n.a.	1.0	28.9	19.7	9.5	44.8	9.0	23.0	43.1	37.7	78.4
SD	n.a.	4.7	62.0	36.7	12.7	54.2	26.0	38.7	73.0	82.0	192.3
Med	n.a.	0.0	5.5	2.9	1.2	21.0	0.0	7.6	6.8	0.0	5.1
Max	n.a.	32.6	439.7	216.1	48.8	176.2	178.4	159.1	307.2	319.2	1149.9

Chaetognaths

January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	63	70	63	71	72	71	61	40		60	44
Mean	n.a.	3.1	0.2	84.7	11.9	20.1	3.3	63.9	n.a.	57.4	139.8
SD	n.a.	7.9	0.5	159.5	25.1	26.1	5.2	159.1	n.a.	110.9	221.1
Med	n.a.	0.0	0.0	30.0	4.2	10.3	0.9	14.7	n.a.	11.3	76.6
Max	n.a.	41.3	2.2	781.8	184.9	120.4	24.7	960.2	n.a.	660.7	1283.4
February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N	67	67	70	71	72	16	61	39	60	57	44
Mean	n.a.	0.7	21.8	330.2	58.4	18.4	8.9	147.4	792.3	93.5	1073.1
SD	n.a.	4.2	87.7	404.6	72.3	23.9	23.3	261.4	1543.7	173.4	1210.4
Med	n.a.	0.0	0.0	161.0	31.8	5.5	1.0	48.7	229.4	10.5	435.6
Max	n.a.	34.9	578.9	1769.9	383.8	77.9	124.7	1146.6	8221.0	836.9	5052.6

Table 4.8. Maturity stage composition of krill collected in the Elephant Island area during 2002 compared to 1992-2001. Advanced maturity stages are proportions of mature females that are (A) 3c-3e in January-February and (B) 3d-3e in February-March. Data are not available for January-February, 2000.

A. SURVEY A	ELEPHANT ISLAND AREA KRILL JANUARY-FEBRUARY										
Stage	1992 %	1993 %	1994 %	1995 %	1996 %	1997 %	1998 %	1999 %	2000 %	2001 %	2002 %
Juveniles	37.1	7.2	4.0	4.6	55.0	15.2	18.4	0.4	n.a.	9.7	46.3
Immature	19.1	30.7	18.8	4.0	18.3	30.6	31.7	11.7	n.a.	6.2	9.0
Mature	43.9	62.2	77.2	91.4	26.7	54.2	49.9	87.9	n.a.	84.1	44.7
Females:											
F2	0.8	7.8	2.3	0.1	1.1	6.3	9.1	1.6	n.a.	0.2	0.4
F3a	0.6	11.7	18.0	0.2	0.0	3.5	21.4	1.7	n.a.	0.9	0.5
F3b	12.3	14.3	19.3	1.2	0.2	0.6	9.0	1.8	n.a.	14.6	2.3
F3c	9.2	5.1	20.1	15.3	1.9	6.9	1.0	14.7	n.a.	13.2	13.7
F3d	0.4	1.2	2.3	17.7	0.7	6.1	0.3	23.9	n.a.	7.4	10.0
F3e	0.0	0.0	0.0	3.7	11.6	7.4	0.7	9.2	n.a.	1.3	6.2
Advanced Stages	42.7	19.5	37.5	96.3	98.3	83.2	6.2	93.2	n.a.	58.5	91.6
Males:											
M2a	8.7	6.8	0.3	0.9	14.6	14.6	8.5	2.2	n.a.	2.1	3
M2b	7.3	11.9	9.4	1.5	2.1	8.2	8.4	3.9	n.a.	2.1	4
M2c	2.3	4.2	6.8	1.5	0.5	1.5	5.7	4.1	n.a.	1.7	1.5
M3a	2.8	3.7	4.3	4.4	1.4	1.5	3.1	1.7	n.a.	2.1	1.7
M3b	18.7	26.2	13.2	48.9	10.9	28.1	14.4	34.9	n.a.	44.6	10.4
Male:Female ratio	1.7	1.3	0.5	1.5	1.9	1.8	1.0	0.9	n.a.	1.4	0.6
No. measured	2472	4283	2078	2294	4296	3209	3600	751	n.a.	2063	1437

B. SURVEY D	FEBRUARY-MARCH										
Stage	1992 %	1993 %	1994 %	1995 %	1996 %	1997 %	1998 %	1999 %	2000 %	2001 %	2002 %
Juveniles	33.6	3.5	3.7	1.1	20.8	8.0	3.6	0.0	0.1	13.4	38.9
Immature	27.1	51.4	6.2	2.5	9.9	19.7	25.4	1.3	2.3	14.7	17.3
Mature	39.2	45.1	90.1	96.4	69.3	72.3	71.0	98.7	97.5	71.9	43.8
Females:											
F2	0.8	21.8	0.7	0.3	0.6	1.1	6.9	0.0	0.2	0.7	3.3
F3a	10.3	12.4	3.5	0.0	0.0	0.1	10.9	0.4	1.0	2.4	0.9
F3b	10.2	6.2	7.8	0.0	0.0	0.0	11.8	0.0	0.7	0.2	0.2
F3c	4.3	3.7	4.3	2.0	5.0	1.8	3.0	11.1	6.5	1.5	2.2
F3d	1.2	1.1	4.6	21.8	10.9	29.1	1.3	47.3	21.9	3.8	14.7
F3e	<0.01	1.2	0.9	20.4	4.9	7.3	0.1	4.8	22.0	42.6	3.6
Advanced Stages	4.6	9.3	26.1	95.5	76.0	95.0	5.2	81.8	84.2	91.8	85.2
Males:											
M2a	4.3	6.9	0.2	0.7	6.5	8.6	1.9	0.0	0.1	4.1	8.8
M2b	19.8	19.1	1.2	0.4	1.2	8.8	6.6	0.7	0.7	2.7	3.6
M2c	2.2	3.6	4.2	1.1	1.6	1.2	10.0	0.6	1.3	7.3	1.6
M3a	2.5	2.1	24.1	4.4	5.3	3.7	17.5	2.6	7.4	2.2	0.3
M3b	10.7	18.4	44.7	47.8	43.2	30.3	26.2	32.4	38.0	19.2	22.1
Male:Female ratio	1.5	1.1	3.4	1.2	2.7	1.3	1.9	0.6	0.9	0.7	1.5
No. measured	3646	3669	1155	1271	2984	560	3153	1176	1371	1739	558

Table 4.9. Salp and krill carbon biomass (mg C per m^2) in the Elephant Island Area during 1995-2002 surveys. N is number of samples. Salp:Krill ratio is based on median values.

	January-February															
	1995		1996		1997		1998		1999		2000		2001		2002	
Biomass	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill
Mean	7.8	242.3	20.2	337.3	334.5	229.0	430.8	173.1	151.8	48.6	n.a.	n.a.	334.5	248.5	287.4	218.6
SD	16.1	201.1	30.9	756.1	1115.6	522.1	565.3	290.6	166.1	66.1	n.a.	n.a.	272.8	425.3	418.3	552.0
Median	1.3	43.5	10.0	72.2	108.9	45.1	187.0	46.7	93.2	14.5	n.a.	n.a.	251.7	81.0	127.0	37.6
Maximum	75.3	1545.2	134.2	4721.0	9434.6	3115.5	2699.0	1488.4	882.7	304.4	n.a.	n.a.	1395.1	2561.2	1855.4	3509.2
N	57	71	72	72	71	71	61	60	40	40	n.a.	n.a.	60	60	44	44
Salp:Krill Ratio	0.03		0.1		2.4		4.0		6.4		n.a.		3.1		3.4	

	February-March															
	1995		1996		1997		1998		1999		2000		2001		2002	
Biomass	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill
Mean	13.1	59.2	50.7	1702.3	1139.7	313.1	694.6	1555.8	321.9	451.0	741.2	204.4	333.9	890.3	738.4	62.3
SD	47.3	149.1	146.5	12441.6	1269.8	655.2	1121.2	8218.7	335.1	2082.6	2314.9	507.6	352.4	4116.8	2129.0	179.5
Median	0.7	13.1	4.6	40.7	504.8	50.0	379.4	31.6	193.5	6.9	239.0	42.8	216.3	45.9	327.1	2.7
Maximum	325.2	1107.1	954.0	106458.5	4645.4	2638.7	8543.0	62155.8	1698.1	13133.1	16400.1	3634.6	1702.8	30967.9	14362.1	1062.6
N	71	71	72	72	16	16	61	60	39	39	60	60	57	57	44	44
Salp:Krill Ratio	0.1		0.1		10.1		12.0		28.0		5.6		4.7		121.1	

Table 4.10. Abundance of biomass dominant copepod species in the Elephant Island area during various cruises 1981-2002. 1981-1990 data provided by John Wormuth. Abundance is numbers per 1000 m^3. n.a. indicates that data are not available.

SURVEY PERIOD		*Calanoides acutus*	*Calanus propinquus*	*Metridia gerlachei*	*Rhincalanus gigas*	*Pleuromama robusta*	*Pareuchaeta antarctica*	*Haloptilus ocellatus*	Copepodites	Other Copepods	Total Copepods
Jan-Feb 88	Mean	429.7	93.6	1639.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2162.3
N=48	STD	676.8	104.3	3488.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3928.6
	Median	80.5	45.5	57.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	618.5
Jan 90	Mean	302.5	354.4	981.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1700.2
N=23	STD	405.8	365.8	1620.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2003.7
	Median	170.1	243.6	192.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	656.7
Jan 99	Mean	335.4	109.1	340.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	927.0
N=40	STD	1009.5	161.9	512.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1590.8
	Median	28.9	52.0	66.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	332.9
Jan 01	Mean	241.0	50.4	1003.2	20.2	5.5	0.2	0.0	n.a.	197.5	1003.2
N=60	STD	392.0	85.9	1582.4	74.8	21.0	0.6	0.0	n.a.	527.3	1582.4
	Median	117.7	12.5	252.2	0.0	0.0	0.0	0.0	n.a.	41.8	252.2
Jan 02	Mean	2931.3	1862.2	350.8	141.6	1.4	122.7	0.0	30.2	44.2	5484.3
N=44	STD	8293.0	5659.2	467.6	381.0	6.3	185.6	0.0	154.1	89.0	14585.6
	Median	876.4	502.7	130.3	16.4	0.0	57.7	0.0	0.0	11.0	2174.9

SURVEY PERIOD		*Calanoides acutus*	*Calanus propinquus*	*Metridia gerlachei*	*Rhincalanus gigas*	*Pleuromama robusta*	*Pareuchaeta antarctica*	*Haloptilus ocellatus*	Copepodites	Other Copepods	Total Copepods
Mar 81	Mean	4786.9	5925.8	2402.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	13115.2
N=10	STD	5482.2	6451.6	3321.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12799.9
	Median	2197.7	2048.7	609.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	8466.8
Feb-Mar 84	Mean	25.5	121.7	1154.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1301.6
N=13	STD	29.6	134.4	2999.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3043.9
	Median	16.2	51.4	23.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	96.6
Feb 89	Mean	161.4	194.9	3189.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3545.6
N=25	STD	240.9	151.5	4017.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4071.5
	Median	88.0	162.0	1051.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1776.0
Feb 99	Mean	511.8	300.9	521.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1557.9
N=39	STD	1395.6	630.6	699.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2337.8
	Median	70.7	70.8	216.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	621.6
Feb 00	Mean	1846.3	741.8	3051.7	1089.0	100.0	107.3	1.5	n.a.	1171.4	8019.1
N=60	STD	3177.2	1546.5	4783.5	2456.5	34.7	249.1	7.8	n.a.	28232.0	11824.4
	Median	225.2	193.3	1249.7	79.9	0.0	11.0	0.0	n.a.	297.6	3478.0
Feb-Mar 01	Mean	2540.2	247.1	1450.0	32.4	3.7	74.7	0.4	116.1	37.0	4501.5
N=57	STD	6921.6	402.9	2966.0	129.1	13.6	137.9	2.7	343.8	188.4	8072.4
	Median	111.5	122.2	140.1	0.0	0.0	20.8	0.0	23.2	0.0	1518.0
Feb-Mar 02	Mean	9569.2	3827.4	2515.1	1226.4	30.0	169.3	14.8	5.2	116.0	17473.4
N=44	STD	12553.1	4288.9	3124.5	1952.7	97.2	269.2	66.0	22.5	337.2	20036.9
	Median	4585.6	2037.2	1183.6	246.2	0.0	52.5	0.0	0.0	0.0	7563.8

Table 4.11. Zooplankton and nekton taxa present in the large survey area samples during (A) January 2002 and (B) February-March 2002 compared to 1995-2001 surveys. F is the frequency of occurrence (%) in (N) tows. Mean is number per 1000 m^3. n.a. indicates taxon was not enumerated. (L) and (J) denote larval and juvenile stages. Dashes denote previously unrecorded taxa.

A. SURVEY A	JANUARY-FEBRUARY															
	2002 N=95		2001 N=101		2000 N=0		1999 N=75		1998 N=105		1997 N=105		1996 N=91		1995 N=90	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Copepods	100.0	7536.2	100.0	2247.1	n.a.	n.a.	100.0	711.6	94.2	56.5	100.0	582.6	100.0	794.4	98.9	652.7
Thysanoessa macrura	92.6	222.6	93.1	73.5	n.a.	n.a.	93.3	135.1	100.0	180.8	97.1	104.4	98.9	106.9	91.1	96.4
Thysanoessa macrura (L)	90.5	1428.1	85.1	458.0	n.a.	n.a.	69.3	72.5	1.9	0.0	44.8	17.0	90.1	308.5	36.7	15.9
Salpa thompsoni	88.4	267.7	100.0	520.7	n.a.	n.a.	100.0	163.3	100.0	808.2	97.1	181.4	64.8	20.4	66.7	16.0
Themisto gaudichaudii	86.3	32.5	66.3	4.0	n.a.	n.a.	32.0	0.3	31.7	0.3	92.4	3.6	92.3	4.9	76.7	4.9
Chaetognaths	81.1	170.9	84.2	174.2	n.a.	n.a.	49.3	47.8	42.3	8.9	74.3	22.9	68.1	12.5	98.9	79.7
Clio pyramidata sulcata	75.8	53.4	32.7	5.9	n.a.	n.a.	9.3	0.1	4.8	0.3	2.9	0.0	6.6	0.1	72.2	5.3
Euphausia superba	74.7	65.5	89.1	27.7	n.a.	n.a.	60.0	6.1	92.3	36.8	93.3	40.4	96.7	112.5	87.8	14.5
Spongiobranchaea australis	69.5	1.9	68.3	2.1	n.a.	n.a.	69.3	1.4	45.2	0.9	67.6	2.2	47.3	1.8	64.4	0.5
Vibilia antarctica	66.3	3.9	98.0	16.3	n.a.	n.a.	94.7	3.8	96.2	13.2	70.5	2.5	48.4	0.5	22.2	0.2
Hyperiella dilatata	53.7	1.3	24.8	0.4	n.a.	n.a.	52.0	0.5	39.4	0.4	56.2	2.2	41.8	0.6	54.4	0.3
Primno macropa	52.6	6.3	7.9	0.1	n.a.	n.a.	69.3	2.5	26.0	0.7	63.8	4.3	20.9	0.1	20.0	0.1
Tomopteris spp.	46.3	3.0	45.5	1.9	n.a.	n.a.	56.0	2.0	31.7	1.3	54.3	1.9	60.4	0.9	84.4	4.2
Cyllopus magellanicus	44.2	3.3	30.7	0.5	n.a.	n.a.	78.7	2.0	64.4	1.9	76.2	3.8	41.8	1.6	24.4	0.2
Euphausia frigida	42.1	20.5	45.5	28.8	n.a.	n.a.	32.0	9.0	5.8	0.2	41.9	14.8	30.8	1.9	50.0	9.8
Radiolaria	42.1	1030.2	19.8	46.1	n.a.	n.a.	40.0	8.9	27.9	0.7	41.0	1.8	12.1	0.1	0.0	0.0
Clione limacina	40.0	2.3	26.7	0.9	n.a.	n.a.	17.3	0.1	38.5	0.9	21.9	0.3	56.0	2.1	41.1	0.5
Cyllopus lucasii	34.7	1.4	87.1	22.4	n.a.	n.a.	6.7	0.0	20.2	0.5	49.5	0.4	11.0	0.1	22.2	0.5
Euphausia superba (L)	28.4	19.4	68.3	160.2	n.a.	n.a.	65.3	103.1	11.5	1.0	55.2	15.2	22.0	2.7	22.2	135.8
Ostracods	28.4	111.0	37.6	6.7	n.a.	n.a.	49.3	2.8	51.0	4.8	41.0	5.5	53.8	4.9	56.7	9.7
Lepidonotothen larseni (L)	18.9	3.8	10.9	0.7	n.a.	n.a.	20.0	0.2	23.1	0.5	27.6	1.8	22.0	0.2	40.0	1.1
Diphyes antarctica	15.8	0.4	23.8	0.5	n.a.	n.a.	34.7	0.5	37.5	1.1	9.5	0.2	17.6	0.1	58.9	1.0
Hydromedusae	15.8	0.4	14.9	0.4	n.a.	n.a.	37.3	0.2	0.0	0.0	20.0	0.1	4.4	0.0	6.7	0.1
Polychaetes	15.8	6.7	7.9	0.7	n.a.	n.a.	20.0	0.6	28.8	1.5	1.0	0.0	1.1	0.0	0.0	0.0
Dimophyes arctica	13.7	0.6	10.9	0.2	n.a.	n.a.	6.7	0.1	2.9	0.1	19.0	0.3	15.4	0.1	25.6	0.8
Limacina helicina	12.6	0.8	51.5	4.9	n.a.	n.a.	61.3	2.4	73.1	8.1	47.6	2.9	74.7	33.7	43.3	1.9
Ihlea racovitzai	12.6	1.1	12.9	1.1	n.a.	n.a.	25.3	3.3	5.8	41.5	n.a	n.a	n.a	n.a	n.a	n.a
Euphausia crystallorophorias	12.6	16.5	1.0	0.0	n.a.	n.a.	9.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
Hyperiella spp.	11.6	0.1	5.9	0.1	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausia spp. (L)	11.6	93.5	0.0	0.0	n.a.	n.a.	10.7	11.1	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Decapods (unid.)	9.5	14.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Larval Fish	8.4	3.3	18.8	0.6	n.a.	n.a.	9.3	0.1	8.7	0.1	0.0	0.0	1.1	0.0	0.0	0.0
Lepidonotothen kempi (L)	8.4	0.3	7.9	0.4	n.a.	n.a.	6.7	0.0	13.5	0.3	32.4	0.6	30.8	0.3	20.0	0.1
Euphausia triacantha	7.4	0.8	13.9	1.6	n.a.	n.a.	17.3	0.4	7.7	0.3	18.1	1.4	15.4	0.5	33.3	1.5
Lepidonotothen nudifrons (L)	5.3	0.1	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	8.9	0.1
Hyperiids	4.2	0.5	12.9	0.7	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notolepis coatsi (L)	4.2	0.0	1.0	0.0	n.a.	n.a.	5.3	0.0	3.8	0.0	6.7	0.0	8.8	0.0	27.8	0.1
Trematomus newnesi (L)	4.2	0.1	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Prionodraco evansii (J)	4.2	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Electrona spp. (L)	3.2	0.0	10.9	0.4	n.a.	n.a.	24.0	0.2	10.6	0.2	37.1	1.4	27.5	0.7	61.1	2.5
Electrona antarctica	3.2	0.0	5.9	0.0	n.a.	n.a.	1.3	0.0	3.8	0.1	9.5	0.0	13.2	0.0	13.3	0.1
Sipunculids	3.2	0.0	3.0	0.0	n.a.	n.a.	10.7	0.0	11.5	0.1	10.5	0.1	7.7	0.0	24.4	0.1
Cyllopus spp.	3.2	0.0	2.0	0.0	n.a.	n.a.	28.0	0.4	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Mysids	3.2	0.1	1.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperiella macronyx	3.2	0.0	0.0	0.0	n.a.	n.a.	2.7	0.0	2.9	0.1	8.6	0.1	5.5	0.0	23.3	0.1
Decapods (L)	3.2	1.7	0.0	0.0	n.a.	n.a.	1.3	0.0	2.9	0.0	0.0	0.0	2.2	0.2	0.0	0.0
Bathylagus sp. (L)	3.2	0.3	0.0	0.0	n.a.	n.a.	0.0	0.0	1.0	0.0	1.0	0.0	2.2	0.0	8.9	0.0
Isopods	3.2	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Beroe cucumis	2.1	0.0	20.8	0.3	n.a.	n.a.	4.0	0.0	3.8	0.0	15.2	0.1	7.7	0.0	12.2	0.0
Vanadis antarctica	2.1	0.0	5.0	0.1	n.a.	n.a.	5.3	0.1	4.8	0.1	1.0	0.0	4.4	0.0	15.6	0.1
Siphonophora	2.1	0.0	3.0	0.3	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electrona carlsbergi	2.1	0.0	2.0	0.0	n.a.	n.a.	2.7	0.0	1.0	0.0	10.5	0.1	n.a.	n.a.	n.a.	n.a.
Schyphomedusae	2.1	0.0	2.0	0.0	n.a.	n.a.	1.3	0.0	1.9	0.0	1.0	0.0	13.2	0.1	0.0	0.0
Cumacea	2.1	2.7	1.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	3.8	0.4	1.1	0.0	0.0	0.0
Acanthophyra pelagica	2.1	1.5	0.0	0.0	n.a.	n.a.	17.3	0.2	3.8	0.0	9.5	0.1	0.0	0.0	22.2	0.1
Chionodraco rastrospinosus (L)	2.1	0.0	0.0	0.0	n.a.	n.a.	1.3	0.0	1.9	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Modeeria rotunda?	2.1	0.2	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Pleurobrachia pileus	2.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Notothenia spp. (L)	2.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Clio pyramidata antarctica?	2.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Gastropods	2.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Chromatonema rubra?	2.1	0.1	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Zanclonia weldoni?	2.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Unid. Eggs	2.1	10.1	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Ctenophores	1.1	0.0	5.0	0.1	n.a.	n.a.	6.7	0.0	3.8	0.1	16.2	0.1	0.0	0.0	6.7	0.0
Hyperoche medusarum	1.1	0.0	5.0	0.1	n.a.	n.a.	5.3	0.0	1.0	0.0	1.0	0.0	3.3	0.0	18.9	0.0

Table 4.11. (Contd.)

A. SURVEY A	JANUARY -FEBRUARY															
	2002		2001		2000		1999		1998		1997		1996		1995	
	N=95		N=101		N=0		N=75		N=105		N=105		N=91		N=90	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Calycopsis borchgrevinki	1.1	0.0	4.0	0.2	n.a.	n.a.	2.7	0.0	1.0	0.0	2.9	0.0	2.2	0.0	1.1	0.0
Pleuragramma antarcticum (J)	1.1	0.0	4.0	0.1	n.a.	n.a.	1.3	0.1	4.8	0.0	2.9	0.0	1.1	0.0	2.2	0.0
Pelagobia longicirrata	1.1	0.0	3.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	0.0	0.0
Gymnoscopelus braueri	1.1	0.0	1.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electrona subaspera	1.1	0.0	1.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	n.a.	n.a.	n.a.	n.a.
Hyperia antarctica	1.1	0.0	1.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0
Bolinopsis infundibulus	1.1	0.0	0.0	0.0	n.a.	n.a.	5.3	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gammarids	1.1	0.0	0.0	0.0	n.a.	n.a.	2.7	0.0	1.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Gobionotothen gibberifrons (L)	1.1	0.0	0.0	0.0	n.a.	n.a.	1.3	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Pegantha margaton	1.1	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Orchomene plebs	1.1	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	1.0	0.0	2.9	0.0	1.1	0.0	4.4	0.0
Gymnoscopelus nicholsi	1.1	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.9	0.0	1.1	0.0	1.1	0.0
Eusirus antarcticus	1.1	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	1.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Hyperiella antarctica	1.1	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	2.2	0.0
Artededraco mirus (L)	1.1	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Krefftichthys anderssoni (L)	1.1	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0
Trematomus scotti (L)	1.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Pasiaphaea sp. (L)	1.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Parachaenechthys charcoti (L)	1.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Schizobrachium polycotylum?	1.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Trematomus lepidorhinus (L)	1.1	0.1	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Clione antarctica	1.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Staurophora mertensi ?	1.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Crustacean larvae	1.1	0.8	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Spongiobranchaea sp.	1.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Lepidonotothen larseni (J)	1.1	0.0	—	—	n.a.	n.a.	—	—	—	—	—	—	—	—	—	—
Beroe forskalii	0.0	0.0	17.8	0.2	n.a.	n.a.	2.7	0.0	1.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Jellies	0.0	0.0	16.8	0.6	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Botrynema brucei	0.0	0.0	5.0	0.1	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Notolepis spp. (L)	0.0	0.0	2.0	0.0	n.a.	n.a.	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhynchonereella bongraini	0.0	0.0	1.0	0.0	n.a.	n.a.	33.3	0.8	9.6	0.2	4.8	0.1	2.2	0.0	3.3	0.1
Orchomene rossi	0.0	0.0	1.0	0.0	n.a.	n.a.	4.0	0.0	0.0	0.0	8.6	0.0	0.0	0.0	5.6	0.0
Eusirus perdentatus	0.0	0.0	1.0	0.0	n.a.	n.a.	1.3	0.0	0.0	0.0	0.0	0.0	1.1	0.0	22.2	0.1
Cephalopods	0.0	0.0	1.0	0.0	n.a.	n.a.	1.3	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
Maupasia coeca	0.0	0.0	1.0	0.0	n.a.	n.a.	1.3	0.0	0.0	0.0	1.9	0.0	1.1	0.0	0.0	0.0
Epimeriella macronyx	0.0	0.0	1.0	0.0	n.a.	n.a.	0.0	0.0	5.8	0.2	1.9	1.4	1.1	0.0	8.9	0.0
Scina spp.	0.0	0.0	1.0	0.1	n.a.	n.a.	0.0	0.0	0.0	0.0	4.8	0.1	0.0	0.0	0.0	0.0
Notolepis annulata (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	2.7	0.0	0.0	0.0	1.0	0.0	0.0	0.0	13.3	0.0
Vogtia serrata	0.0	0.0	0.0	0.0	n.a.	n.a.	1.3	0.0	0.0	0.0	3.8	0.1	0.0	0.0	0.0	0.0
Fish Eggs	0.0	0.0	0.0	0.0	n.a.	n.a.	1.3	0.0	1.0	0.0	2.9	0.1	1.1	0.0	4.4	0.0
Bylgides pelagica	0.0	0.0	0.0	0.0	n.a.	n.a.	1.3	0.0	0.0	0.0	2.9	0.1	0.0	0.0	5.6	0.0
Notothenia coriiceps (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Patagonitothen b. guntheri (J)	0.0	0.0	0.0	0.0	n.a.	n.a.	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Periphylla periphylla	0.0	0.0	0.0	0.0	n.a.	n.a.	1.3	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1	0.0
Thyphloscolex muelleri	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.0	0.0	4.4	0.0	0.0	0.0
Travisiopsis levinseni	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Travisiopsis coniceps	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Chaenodraco wilsoni (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaenocephalus aceratus (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chorismus antarcticus	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Cyphocaris richardi	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	4.4	0.0
Cryodraco antarctica (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Artededraco skottsbergi (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Arctapodema ampla	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Artededraco sp. B (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Bolinopsis sp.	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Atolla wyvillei	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	2.9	0.0	1.1	0.0	7.8	0.0
Euphysora gigantea	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
Hyperia macrocephala	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	1.0	0.1	1.0	0.0	0.0	0.0	3.3	0.0
Harpagifer antarcticus (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Krefftichthys anderssoni	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Phalacrophorus pictus	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Oediceroides calmani	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Eusirus sp.	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eusirus microps	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
Gosea brachyura	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0
Gymnoscopelus opisthopteris	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	3.8	0.0	2.2	0.0	7.8	0.0
Gymnodraco acuticeps (L)	0.0	0.0	0.0	0.0	n.a.	n.a.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
TOTAL		11143.1		3812.2		n.a.		1294.2		1172.7		1015.2		1408.9		1052.2
NO. TAXA	92		63		n.a.		65		63		70		66		68	

Table 4.11. (Contd.)

B. SURVEY D	FEBRUARY-MARCH															
	2002 N=94		2001 N=97		2000 N=97		1999 N=67		1998 N=104		1997 N=16		1996 N=91		1995 N=89	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Copepods (Total)	100.0	15904.8	99.0	5915.7	99.0	7038.7	100.0	1454.5	97.1	119.0	100.0	1267.8	98.9	1387.0	100.0	3189.1
Chaetognaths	97.9	880.1	77.1	164.5	91.8	632.8	91.0	127.4	61.5	10.7	75.0	18.2	93.4	64.1	100.0	296.4
Themisto gaudichaudii	97.9	30.2	79.2	4.3	83.5	7.2	32.8	0.2	32.7	0.3	87.5	2.9	91.2	2.5	74.2	3.6
Thysanoessa macrura (L)	96.8	1111.5	91.7	718.3	82.5	883.9	74.6	137.4	13.5	2.6	50.0	10.8	87.9	414.4	79.8	276.9
Salpa thompsoni	80.9	621.6	100.0	392.1	96.9	726.2	100.0	248.1	98.1	689.1	100.0	1245.5	62.6	28.2	59.6	16.5
Thysanoessa macrura	79.8	112.8	86.5	639.0	92.8	41.5	98.5	93.1	100.0	177.4	100.0	181.3	91.2	143.3	93.3	161.3
Euphausia frigida	66.0	80.0	50.0	42.0	67.0	49.9	64.2	20.0	29.8	9.3	68.8	44.8	54.9	9.0	60.7	16.7
Euphausia superba	57.4	281.6	79.2	59.0	77.3	21.0	61.2	24.4	89.4	133.5	68.8	30.4	86.8	106.7	78.7	5.7
Primno macropa	57.4	28.2	28.1	1.5	44.3	3.2	65.7	2.6	49.0	1.9	18.8	0.5	63.7	3.5	31.5	0.4
Spongiobranchaea australis	47.9	1.3	70.8	4.1	68.0	2.7	65.7	1.0	38.5	0.8	43.8	2.8	68.1	1.4	60.7	0.4
Vibilia antarctica	46.8	22.2	99.0	10.9	95.9	20.2	98.5	3.6	96.2	8.0	81.3	8.1	48.4	1.0	23.6	0.2
Hyperiella dilatata	38.3	2.6	30.2	0.4	22.7	0.4	56.7	1.2	34.6	0.4	25.0	0.2	52.7	0.8	24.7	0.1
Radiolarians	36.2	7918.3	32.3	216.2	40.2	531.4	40.3	6.3	28.8	1.0	12.5	0.7	34.1	0.9	27.0	0.4
Cyllopus magellanicus	34.0	2.8	70.8	2.9	87.6	10.0	95.5	4.8	81.7	5.6	93.8	3.3	46.2	2.1	25.8	0.7
Cyllopus lucasii	30.9	3.0	96.9	26.6	4.1	0.0	29.9	0.2	57.7	1.6	93.8	2.4	34.1	0.2	23.6	0.5
Euphausia superba (L)	28.7	61.0	64.6	683.4	80.4	2129.6	80.6	49.8	12.5	1.6	37.5	25.0	62.6	13.9	93.3	3690.0
Ostracods	22.3	42.6	20.8	10.1	45.4	25.1	80.6	14.0	43.3	5.4	56.3	4.8	47.3	10.1	75.3	43.4
Euphausia triacantha	22.3	2.2	16.7	1.2	25.8	1.9	22.4	1.8	11.5	0.6	43.8	0.9	22.0	0.8	28.1	1.6
Electrona spp. (L)	20.2	2.2	12.5	0.8	43.3	4.0	20.9	0.3	10.6	0.2	12.5	0.1	38.5	0.9	62.9	5.2
Euphausia frigida (L)	19.1	53.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tomopteris spp.	18.1	1.1	19.8	0.4	23.7	2.3	55.2	2.8	8.7	0.0	31.3	0.5	38.5	0.9	57.3	1.3
Lepidonotothen kempi (L)	18.1	0.3	19.8	0.2	29.9	0.3	16.4	0.1	22.1	0.2	6.3	0.2	39.6	0.4	48.3	0.4
Cyllopus spp.	13.8	0.9	0.0	0.0	25.8	2.9	0.0	0.0	24.0	0.7	24.0	0.7	0.0	0.0	0.0	0.0
Notolepis coatsi (L)	12.8	0.2	2.1	0.0	6.2	0.0	0.0	0.0	4.8	0.0	0.0	0.0	18.7	0.1	36.0	0.2
Hyperiella spp.	12.8	0.2	0.0	0.0	9.3	0.3	9.0	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electrona antarctica	12.8	0.1	5.2	0.0	15.5	0.1	6.0	0.0	8.7	0.0	31.3	0.2	20.9	0.2	15.7	0.1
Euphausia crystallorophorias	11.7	65.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepidonotothen larseni (L)	11.7	1.8	14.6	0.2	3.1	0.0	11.9	0.0	13.5	0.1	0.0	0.0	13.2	0.3	10.1	0.0
Dimophyes arctica	8.5	0.1	15.6	0.2	15.5	0.6	0.0	0.0	16.3	0.4	12.5	0.1	13.2	0.1	13.5	0.3
Diphyes antarctica	8.5	0.2	20.8	0.2	21.6	0.4	31.3	0.3	29.8	0.4	6.3	0.3	7.7	0.1	23.6	0.4
E. crystallorophorias (L)	6.4	14.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gymnoscopelus braueri	6.4	0.1	7.3	0.0	8.2	0.1	7.5	0.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Zanclonia weldoni?	6.4	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Limacina helicina	5.3	0.6	33.3	1.8	45.4	205.4	26.9	1.9	37.5	0.8	0.0	0.0	24.2	1.9	4.5	0.0
Ihlea racovitzai	5.3	0.3	3.1	0.3	13.4	0.6	26.9	5.1	61.5	51.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Pleuragramma antarcticum (L)	5.3	0.2	5.2	0.1	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	1.1	0.0	2.2	0.0
Clio pyramidata sulcata	5.3	0.2	10.4	0.4	5.2	0.0	13.4	0.1	0.0	0.0	0.0	0.0	3.3	0.0	12.4	0.0
Hydromedusae	5.3	0.0	4.2	0.0	23.7	0.5	40.3	0.3	12.5	0.2	12.5	0.2	3.3	0.1	5.6	0.0
Gammarids	4.3	2.3	4.2	0.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sipunculids	4.3	1.5	12.5	0.3	12.4	0.1	11.9	0.0	4.8	0.1	6.3	0.0	8.8	0.1	9.0	0.0
Clione limacina	4.3	0.1	16.7	0.9	5.2	0.0	3.0	0.0	10.6	0.1	12.5	0.0	15.4	0.2	0.0	0.0
Clio pyramidata antarctica?	4.3	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Clytia sp.?	4.3	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Calycopsis borchgrevinki	4.3	0.0	6.3	0.0	13.4	0.2	19.4	0.4	4.8	0.0	6.3	0.0	6.6	0.0	11.2	0.0
Trematomus scotti (L)	4.3	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphausia spp. (L)	3.2	4.4	1.0	0.4	11.3	4.3	13.4	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromatonema rubra?	3.2	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pegantha margaton	3.2	0.1	27.1	0.3	13.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperoche medusarum	3.2	0.0	10.4	0.1	3.1	0.0	4.5	0.0	0.0	0.0	12.5	0.3	2.2	0.0	12.4	0.0
Mysids	2.1	0.1	1.0	0.1	1.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eusirus antarcticus	2.1	0.0	5.2	0.1	1.0	0.0	1.5	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyphocaris richardi	2.1	0.0	1.0	0.0	3.1	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.1	0.0	3.4	0.1
Lepidonotothen nudifrons (L)	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	3.4	0.0
Modeeria rotunda?	2.1	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Orchomene plebs	2.1	0.0	1.0	0.0	2.1	0.8	0.0	0.0	1.9	0.0	0.0	0.0	2.2	0.0	3.4	0.0
Harpagifer antarcticus (L)	2.1	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Gymnoscopelus nicholsi	2.1	0.0	3.1	0.0	1.0	0.0	1.5	0.0	1.0	0.0	12.5	0.1	3.3	0.0	1.1	0.0
Vanadis antarctica	2.1	0.0	1.0	0.0	4.1	0.1	1.5	0.0	3.8	0.1	0.0	0.0	1.1	0.0	6.7	0.0
Cephalopods	2.1	0.0	1.0	0.0	2.1	0.0	4.5	0.0	1.9	0.0	0.0	0.0	9.9	0.0	0.0	0.0
Bolinopsis spp.	2.1	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cumaceans	1.1	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Scina spp.	1.1	0.0	0.0	0.0	1.0	0.0	1.5	0.0	0.0	0.0	6.3	0.5	2.2	0.0	1.1	0.0
Limacina spp.	1.1	0.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Champsocephalus gunnari (L)	1.1	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Electrona carlsbergi	1.1	0.0	6.3	0.0	1.0	0.0	4.5	0.0	1.9	0.0	0.0	0.0	n.a.	n.a.	n.a.	n.a.
Polychaetes	1.1	0.0	6.3	0.6	18.6	2.6	7.5	0.3	13.5	0.3	0.0	0.0	3.3	0.1	2.2	0.0
Larval Fish	1.1	0.0	1.0	0.0	6.2	0.6	14.9	0.7	1.9	0.1	0.0	0.0	1.1	0.0	0.0	0.0
Pelagobia longicirrata	1.1	0.0	0.0	0.0	5.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notolepis spp. (L)	1.1	0.0	1.0	0.2	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
Beroe cucumis	1.1	0.0	7.3	0.1	2.1	0.0	9.0	0.0	4.8	0.0	0.0	0.0	11.0	0.1	4.5	0.0
Acanthophyra pelagica	1.1	0.0	0.0	0.0	0.0	0.0	3.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	5.6	0.0
Bathydraco antarcticus (L)	1.1	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Orchomene rossi	1.1	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.0	0.0	0.0	0.0	5.5	0.5	6.7	0.0
Periphylla periphylla	1.1	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1	0.0
Hyperiella macronyx	1.1	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	6.3	0.0	6.6	0.1	13.5	0.0
Atolla wyvillei	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Mitrocomella brownei?	1.1	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pyrasoma atlanticum	1.1	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Parachaenechthys charcoti (L)	1.1	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arctapodema ampla	1.1	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 4.11. (Contd.)

B. SURVEY D	FEBRUARY-MARCH															
	2002		2001		2000		1999		1998		1997		1996		1995	
	N=94		N=97		N=97		N=67		N=104		N=16		N=91		N=89	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Euphausia triacantha (L)	1.1	0.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Trematomus centronotus (L)	1.1	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gerlache australis (L)	1.1	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Trematomus newnesi (L)	1.1	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphausiid eggs	0.0	0.0	19.8	9.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Beroe forskalii	0.0	0.0	10.4	0.0	13.4	0.1	9.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Hyperiids	0.0	0.0	5.2	0.3	8.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ctenophora	0.0	0.0	5.2	0.0	6.2	0.1	4.5	0.0	0.0	0.0	6.3	0.0	1.1	0.0	3.4	0.0
Pleurobrachia pileus	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Callianira antarctica	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fish Eggs	0.0	0.0	3.1	0.0	0.0	0.0	1.5	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Siphonophora	0.0	0.0	2.1	0.0	10.3	2.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rhynchonereella bongraini	0.0	0.0	2.1	0.0	5.2	0.6	31.3	2.3	1.0	0.0	0.0	0.0	5.5	0.1	20.2	0.1
Bylgides pelagica	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
Electrona subaspera	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n.a.	n.a.	n.a.	n.a.
Eusirus perdentatus	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.2	0.0	6.7	0.1
Chionodraco rastrospinosus (L)	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Krefftichthys anderssoni (L)	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Botrynema brucei	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Laodicea undulata	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Schyphomedusae	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	12.5	0.0	19.8	0.1	13.5	0.1
Gymnoscopelus bolini	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notothenia coriiceps (L)	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropods	0.0	0.0	0.0	0.0	4.1	17.6	6.0	0.5	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausia spp.	0.0	0.0	0.0	0.0	4.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bolinopsis infundibulus	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leusia spp.	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gobionotothen gibberifrons (L)	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Epimeriella macronyx	0.0	0.0	0.0	0.0	2.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	5.6	0.6
Protomyctophum bolini	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solomondella spp.	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Orchomene spp.	0.0	0.0	0.0	0.0	1.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pasiaphaea sp. (L)	0.0	0.0	0.0	0.0	1.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chorismus antarcticus	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gymnoscopelus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperia macrocephala	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	1.1	0.0	5.6	0.0
Pagothenia brachysoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaenodraco wilsoni (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhynchonereella sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Travisiopsis coniceps	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1	0.0
Eusirus microps	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0
Gymnoscopelus opisthopteris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	10.1	0.0
Bathylagus sp. (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	1.1	0.0	14.6	0.0
Decapods (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Notolepis annulata (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	5.5	0.0	3.4	0.0
Pagetopsis macropterus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Hyperia spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.1	0.0	0.0
Lepidonotothen larseni (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Artedidraco skottsbergi (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		27260.8		8910.2		12378.9		2207.6		1224.4		2854.0		2196.4		7713.3
TAXA	83		61		72		57		59		36		62		61	

Table 4.12. Percent contribution and abundance rank (R) of numerically dominant zooplankton and nekton taxa in the Elephant Island area during (A) January-February and (B) February-March surveys, 1994-2002. Includes the 10 most abundant taxa each year. Radiolarians excluded as a taxonomic category. No samples were collected January-February 2000. n.a. indicates that taxon was not enumerated during other surveys. Shaded column is a "salp year".

A. SURVEY A	JANUARY-FEBRUARY ELEPHANT ISLAND AREA																	
	1994		1995		1996		1997		1998		1999		2000		2001		2002	
TAXON	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R
Copepods	4.08	3	61.54	1	56.18	1	57.16	1	4.80	3	58.05	1	n.a.		46.76	1	75.69	1
Thysanoessa macrura (L)	n.a.		1.50	6	21.82	2	1.67	6	0.00		7.29	4	n.a.		12.55	3	10.67	2
Salpa thompsoni	80.83	1	1.51	5	1.45	6	17.79	2	68.76	1	12.35	2	n.a.		29.03	2	5.66	3
Thysanoessa macrura	7.87	2	9.09	3	7.56	4	10.24	3	15.38	2	2.92	6	n.a.		2.15	5	2.77	4
Chaetognaths	0.04		7.84	4	0.90	7	2.28	5	0.92	7	4.00	5	n.a.		2.68	4	1.93	5
Euphausia superba	2.68	4	1.37	7	7.95	3	3.96	4	3.13	6	0.33	8	n.a.		0.88	10	0.54	6
Euphausia superba (L)	n.a.		12.80	2	0.19	10	1.49	7	0.09		10.95	3	n.a.		1.53	6	0.49	7
Clio pyramidata	0.53	8	0.50	10	0.01		0.00		0.02		0.01		n.a.		0.08		0.46	8
Euphausia frigida	0.38	9	0.92	8	0.14		1.45	8	0.02		1.00	7	n.a.		1.09	7	0.39	9
Themisto gaudichaudii	1.05	6	0.46		0.34	9	0.35		0.03		0.02		n.a.		0.17		0.32	10
Primno macropa	0.05		0.01		0.01		0.42	10	0.06		0.13		n.a.		0.10		0.12	
Ostracods	n.a.		0.91	9	0.35	8	0.54	9	0.41	9	0.13		n.a.		0.25		0.09	
Vibilia antarctica	1.17	5	0.02		0.04		0.24		1.12	6	0.32	9	n.a.		0.98	8	0.06	
Tomopteris spp.	0.25	10	0.40		0.06		0.19		0.11		0.15	10	n.a.		0.11		0.03	
Limacina helicina	0.03		0.18		2.38	5	0.28		0.69	8	0.07		n.a.		0.14		0.03	
Euphausia triacantha	0.12		0.14		0.04		0.14		0.02		0.03		n.a.		0.10		0.02	
Ihlea racovitzai	n.a.		n.a.		n.a.		n.a.		3.53	4	0.15		n.a.		0.02		0.02	
Cyllopus lucasii	0.62	7	0.02		0.11		0.37		0.16	10	0.15		n.a.		0.98	9	0.02	
Spongiobranchaea australis	0.01		0.05		0.13		0.22		0.07		0.09		n.a.		0.09		0.02	
TOTAL	99.69		99.26		99.64		98.79		99.32		98.15		n.a.		99.68		99.341	

B. SURVEY D	FEBRUARY-MARCH ELEPHANT ISLAND AREA																	
	1994		1995		1996		1997		1998		1999		2000		2001		2002	
TAXON	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R
Copepods	82.15	1	40.49	2	62.07	1	44.46	1	7.38	4	62.77	1	54.20	1	64.68	1	83.13	1
Thysanoessa macrura (L)	n.a.		3.76	3	21.40	2	0.38	8	0.03		7.49	3	7.33	3	8.81	3	6.87	2
Chaetognaths	0.47	6	3.61	4	2.43	5	0.65	7	0.60	8	5.94	4	5.35	5	1.34	5	5.11	3
Salpa thompsoni	11.78	2	0.22	7	1.39	6	43.62	2	65.31	1	12.46	2	6.17	4	6.50	4	2.71	4
Euphausia frigida (L)	n.a.		n.a.		n.a.		n.a.		n.a.		n.a.		n.a.		n.a.		0.40	5
Euphausia frigida	0.69	5	0.21	8	0.40	8	1.57	4	0.60	7	1.00	8	0.29	7	0.54	8	0.37	6
Thysanoessa macrura	1.83	3	0.87	5	4.86	4	6.36	3	9.40	3	3.84	5	0.24	8	14.96	2	0.27	7
Euphausia superba (L)	n.a.		50.16	1	0.59	7	0.88	6	0.16		2.71	6	23.14	2	1.03	7	0.20	8
Primno macropa	0.00		0.00		0.15	10	0.02		0.11		0.08		0.02		0.03		0.21	9
Vibilia antarctica	0.16	9	0.00		0.05		0.28	9	0.71	6	0.15		0.18	10	0.21	10	0.16	10
Themisto gaudichaudii	0.27	8	0.01		0.09		0.10		0.01		0.01		0.02		0.07		0.12	
Ostracods	n.a.		0.43	6	0.38	9	0.17	10	0.35	10	0.65	9	0.20	9	0.03		0.06	
Euphausia superba	0.41	7	0.06	10	5.57	3	1.07	5	10.87	2	1.43	7	0.10		1.15	6	0.05	
Cyllopus magellanicus	0.12		0.01		0.10		0.12		0.55	9	0.17		0.07		0.02		0.02	
Electrona spp. (L)	0.75	4	0.07	9	0.04		0.01		0.01		0.01		0.03		0.02		0.02	
Cyllopus lucasii	0.14	10	0.01		0.01		0.08		0.14		0.01		0.00		0.43	9	0.01	
Euphausia triacantha	0.03		0.02		0.03		0.03		0.04		0.06		0.01		0.02		0.01	
Euphausia spp. (L)	n.a.		0.00		0.00		0.00		0.00		0.10		0.04		0.01		0.00	
Limacina helicina	0.00		0.00		0.01		0.00		0.03		0.00		2.21	6	0.00		0.00	
Ihlea racovitzai	n.a.		n.a.		n.a.		n.a.		2.77	5	0.34	10	0.00		0.00		0.00	
TOTAL	98.795		99.94		99.56		99.79		96.28		98.77		99.61		99.856		99.72	

Table 4.13. Percent Similarity Index (PSI) values from comparisons of overall zooplankton composition in the Elephant Island area during Surveys (A) A and (B) D, 1994-2002. Shading denotes the 1998 "salp year".

A.	JANUARY-FEBRUARY PSI VALUES							
Year	1995	1996	1997	1998	1999	2000	2001	2002
1994	16.7	16.6	34.2	85.0	20.9	n.a.	38.7	14.5
1995	xxxxx	70.3	76.8	18.7	80.7	n.a.	58.9	71.7
1996		xxxxx	73.4	19.3	70.0	n.a.	65.9	73.4
1997			xxxxx	38.4	80.2	n.a.	75.7	71.3
1998				xxxxx	22.6	n.a.	39.8	15.2
1999					xxxxx	n.a.	75.1	77.4
2000						xxxxx	n.a.	n.a.
2001							xxxxx	69.2

B.	FEBRUARY-MARCH PSI VALUES							
Year	1995	1996	1997	1998	1999	2000	2001	2002
1994	42.4	66.9	60.1	22.9	78.4	61.8	74.9	86.4
1995	xxxxx	49.1	44.0	10.0	52.4	72.0	48.1	48.9
1996		xxxxx	54.3	21.1	80.3	67.0	80.9	74.1
1997			xxxxx	60.5	65.2	53.6	61.3	49.5
1998				xxxxx	27.7	15.5	26.2	12.0
1999					xxxxx	76.9	85.0	78.7
2000						xxxxx	71.0	70.0
2001							xxxxx	76.8

Table 4.14. Taxonomic composition of two zooplankton clusters during February-March 2002 Survey D. R and % are rank and proportion of total mean abundance represented by each taxon.

	CLUSTER 2 (OCEANIC) N=29					CLUSTER 1 (SHELF AND COASTAL) N=65				
TAXON	R	%	MEAN	STD	MEDIAN	R	%	MEAN	STD	MEDIAN
Radiolarians	1	39.0	25664.6	43458.1	7344.8		0.0	0.8	4.1	0.0
Calanoides acutus	2	24.3	15958.3	16137.8	11410.1	1	36.5	3545.6	5239.0	1730.3
Calanus propinquus	3	15.1	9965.0	13352.4	5597.4	3	18.6	1805.6	3269.1	946.2
Metridia gerlachei	4	6.3	4158.8	4095.8	2643.3	2	19.5	1887.2	2729.1	460.4
Rhincalanus gigas	5	4.8	3170.3	4469.2	1678.2	6	4.2	405.8	802.2	81.9
Thysanoessa macrura (L)	6	4.0	2653.3	3379.8	916.3	5	4.4	423.7	749.3	192.9
Chaetognaths	7	2.8	1867.3	1479.1	1836.2	4	4.5	439.6	599.0	224.8
Salpa thompsoni	8	2.1	1351.3	2106.1	352.6	8	3.1	296.1	633.8	23.8
Other copepods	9	0.5	299.6	541.0	0.0	15	0.3	26.0	89.3	0.0
Pareuchaeta antarctica	10	0.4	263.9	328.4	137.4	10	1.1	104.8	151.7	38.7
Euphausia frigida	11	0.1	87.7	210.4	18.6	11	0.8	76.5	335.6	2.2
Euphausia superba (L)	12	0.1	71.4	168.9	0.0	12	0.6	56.4	239.7	0.0
Ostracods	13	0.1	60.5	128.4	0.0	13	0.4	34.6	107.0	0.0
Vibilia antarctica	14	0.1	58.7	156.9	1.9		0.1	5.9	22.6	0.0
Primno macropa	15	0.1	58.1	158.1	1.8		0.2	14.8	31.7	0.4
Thysanoessa macrura		0.1	57.3	141.6	3.7	9	1.4	137.6	283.9	31.5
Themisto gaudichaudii		0.0	30.7	29.7	16.6	14	0.3	30.0	45.3	17.1
Euphausia superba		0.0	7.1	20.9	0.0	7	4.2	404.0	1700.6	1.3
Cyllopus lucasii		0.0	6.6	18.4	0.0		0.0	1.4	6.0	0.0
Euphausia triacantha		0.0	5.4	8.5	0.0		0.0	0.7	2.7	0.0
Hyperiella dilatata		0.0	4.3	7.7	0.4		0.0	1.8	8.1	0.0
Cyllopus magellanicus		0.0	4.1	12.8	0.0		0.0	2.2	8.7	0.0
Spongiobranchaea australis		0.0	2.4	3.5	1.2		0.0	0.8	2.9	0.0
TOTAL			65806.7					9701.9		

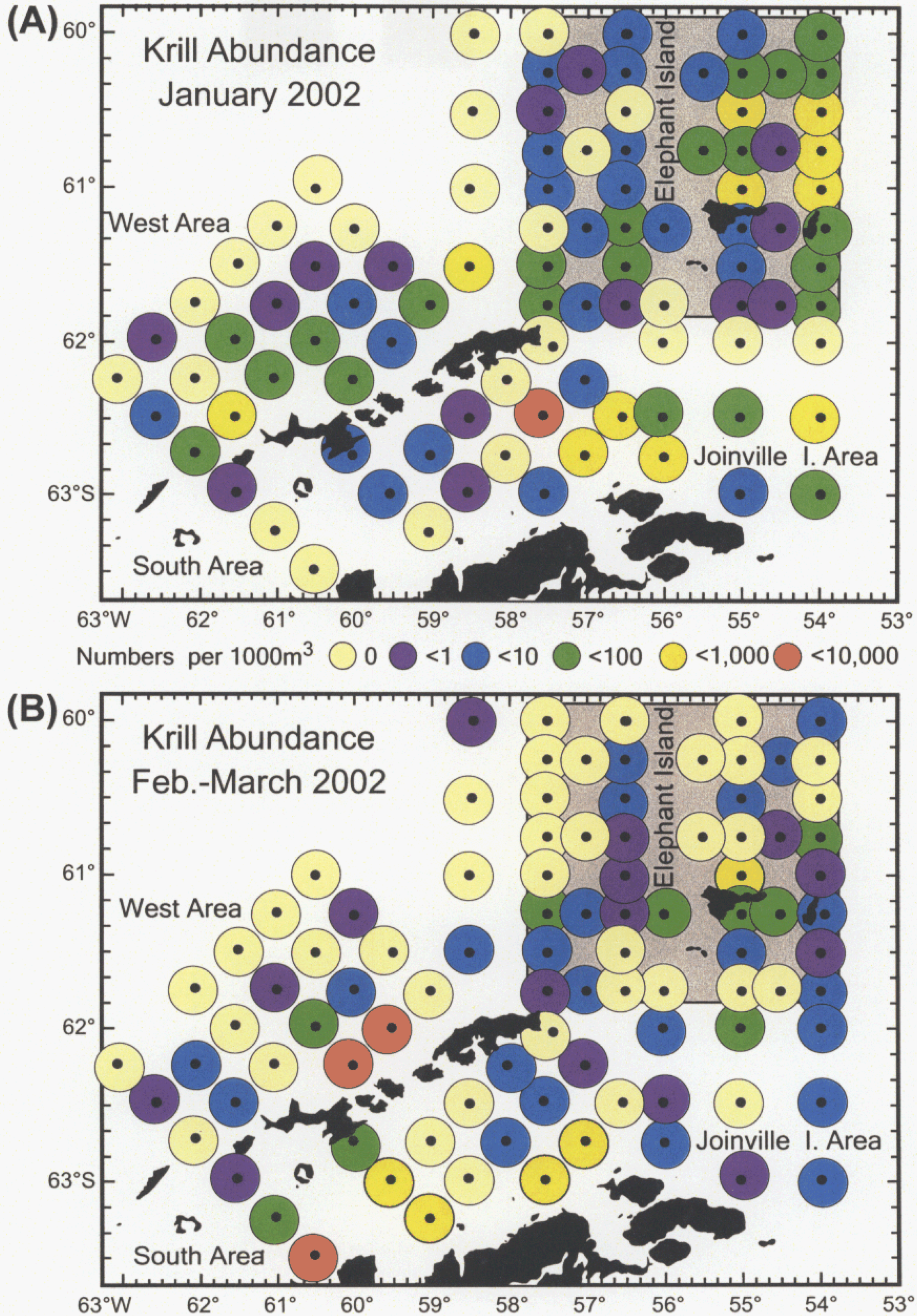
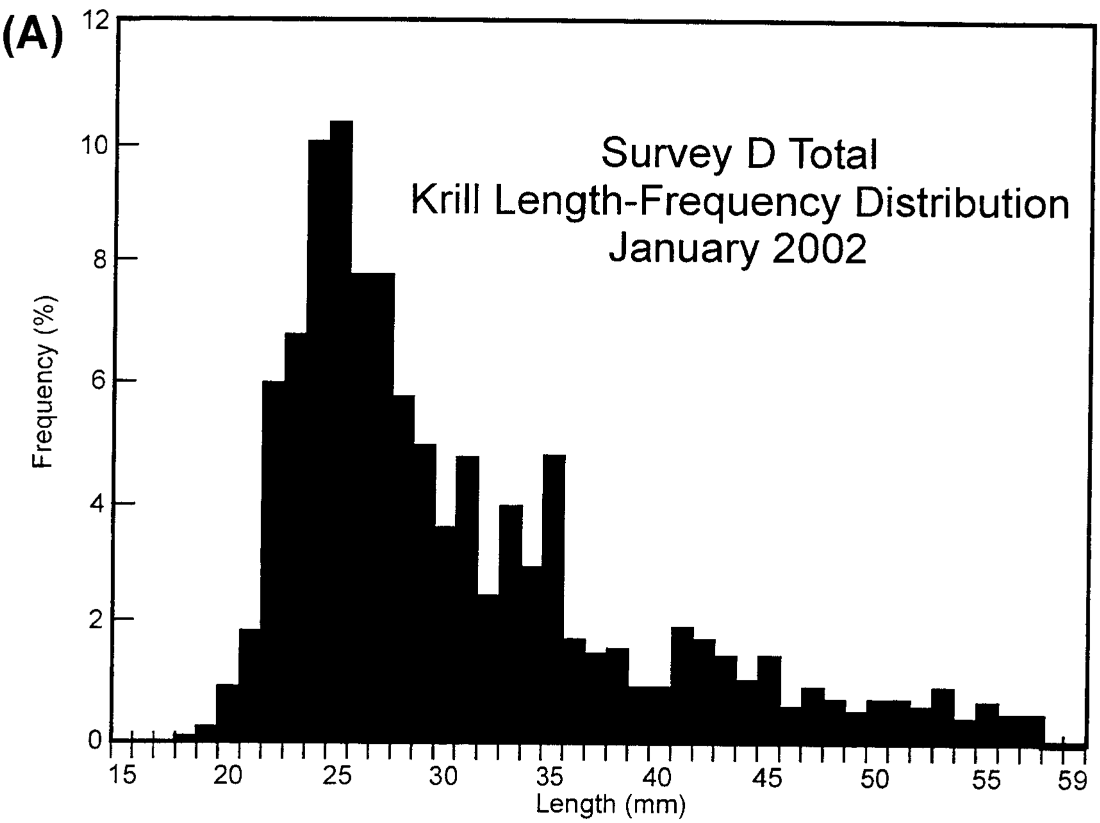


Figure 4.1. Krill abundance in IKMT tows collected during (A) January Survey A and (B) February-March Survey D. The outlined stations are included in the Elephant Island Area and used for between-year comparisons. West, South and Joinville Island Area stations are indicated..

(A)



(B)

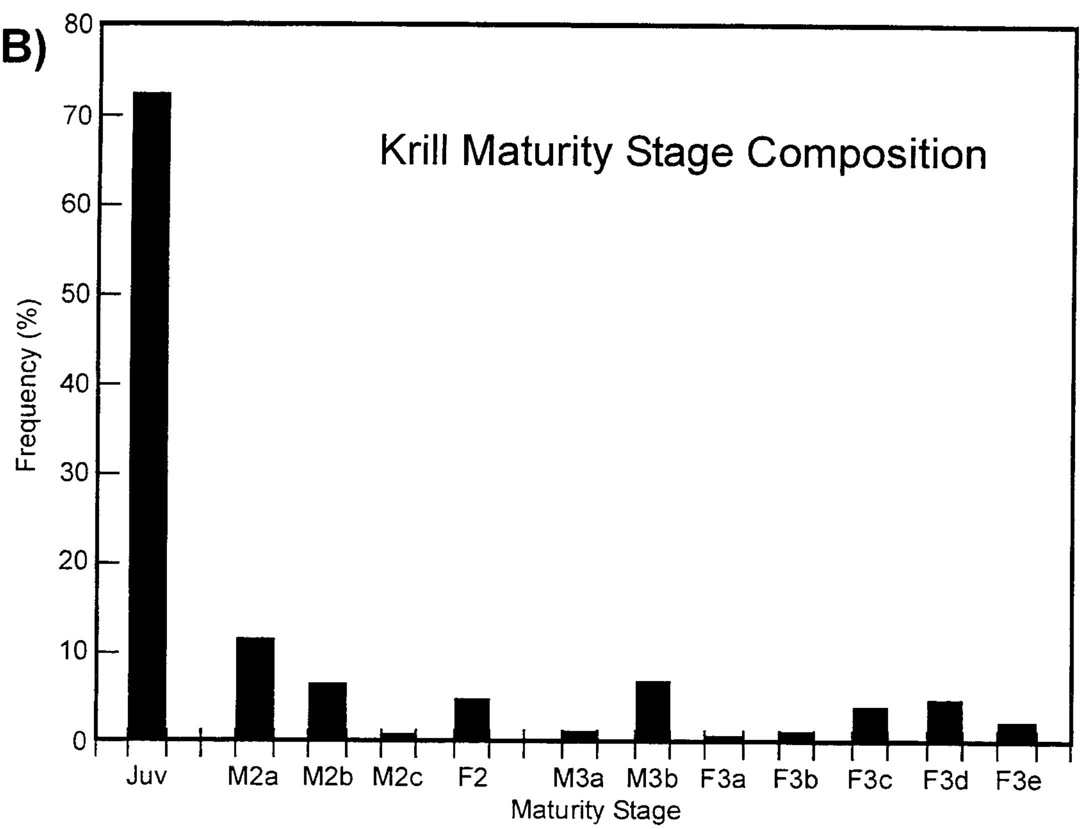


Figure 4.2 Krill (A) length-frequency distribution of krill and (B) maturity stage composition during Survey A.

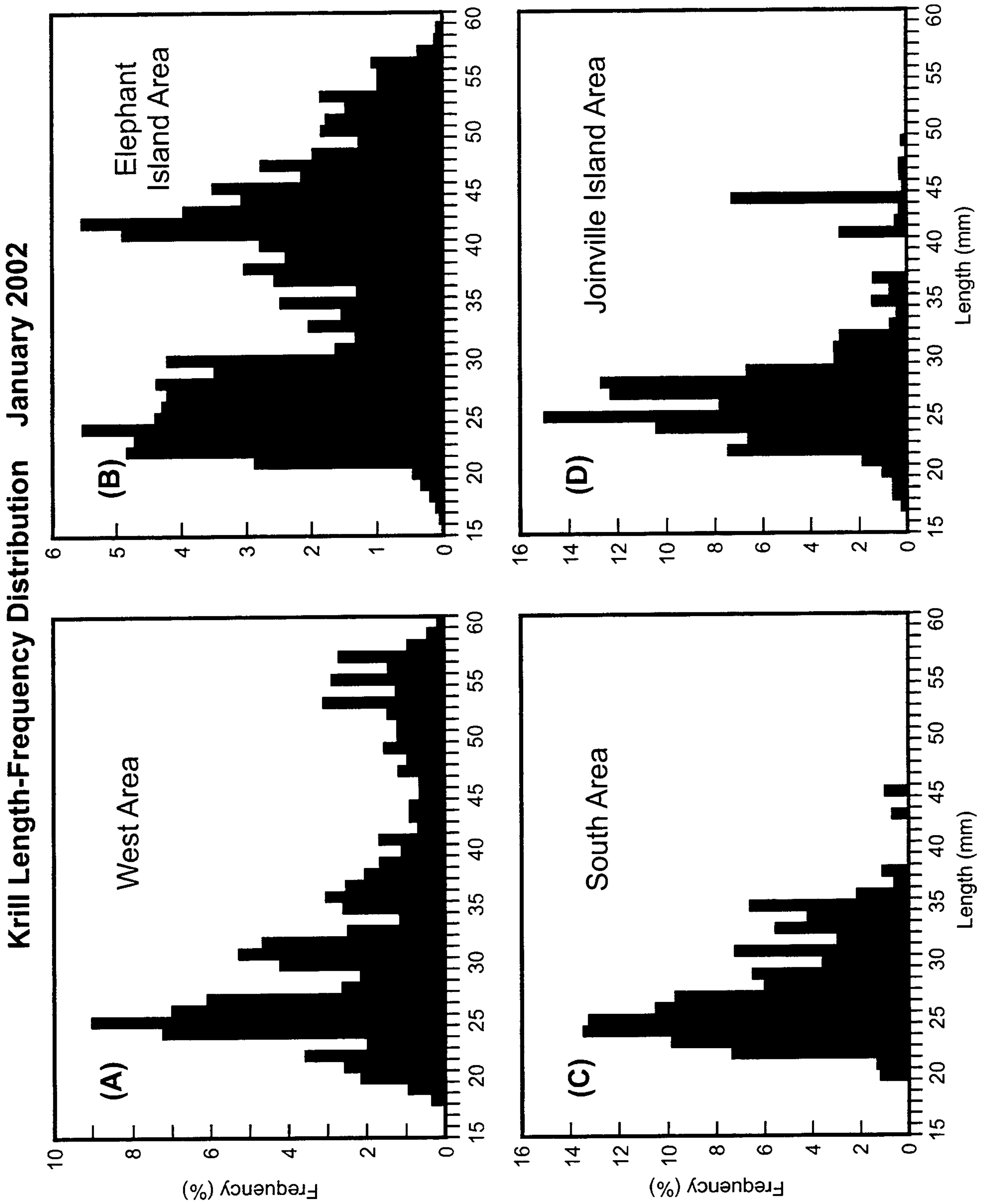


Figure 4.3. Length-frequency distribution of krill collected in the (A) West Area, (B) Elephant Island, (C) South and (D) Joinville Island Areas during Survey A.

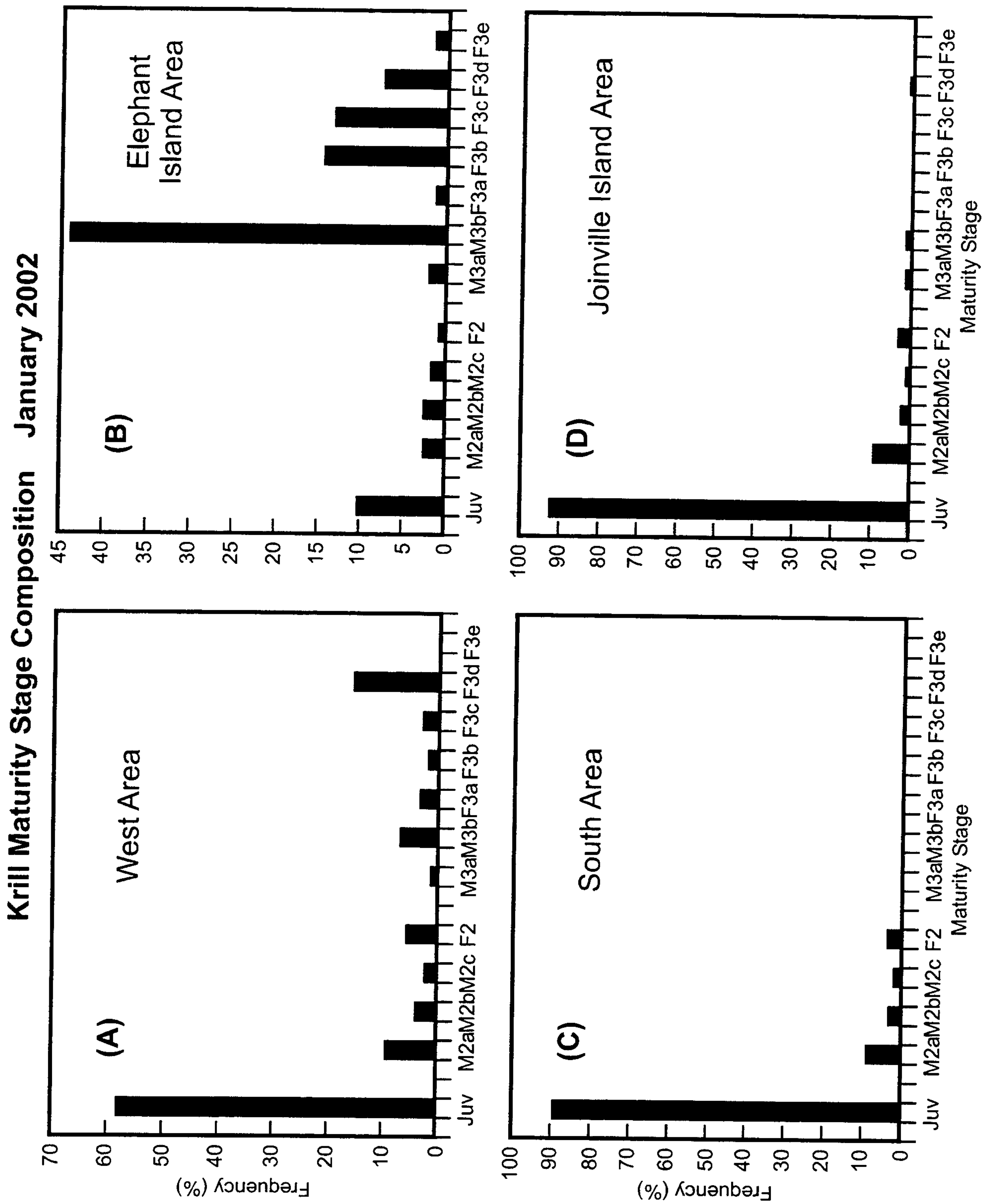


Figure 4.4. Maturity stage composition of krill collected in the (A) West Area, (B) Elephant Island, (C) South and (D) Joinville Island Areas during Survey A.

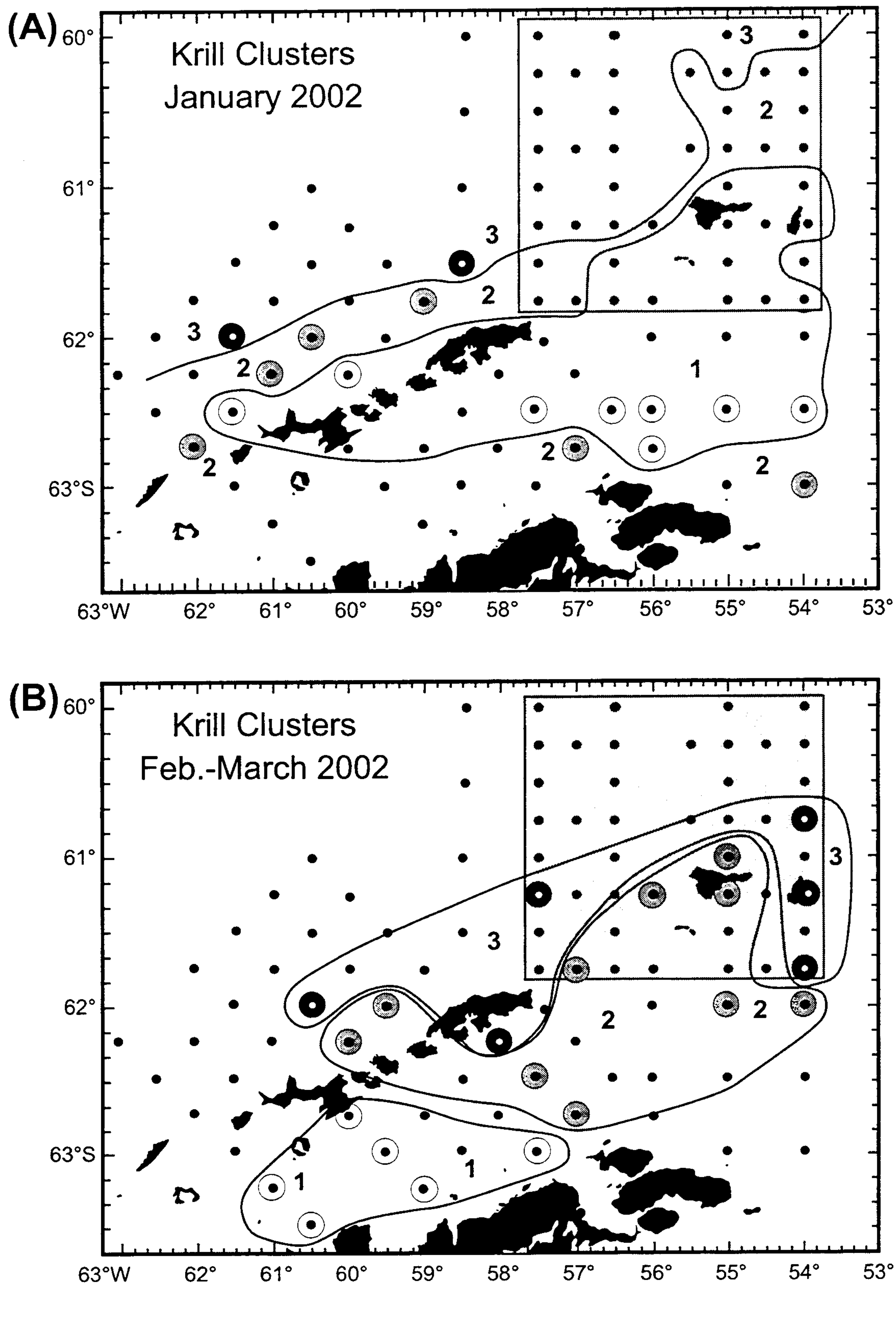


Figure 4.5. Distribution patterns of krill belonging to three length categories (Clusters) within the large survey areas during (A) January Survey A and (B) February-March Survey D.

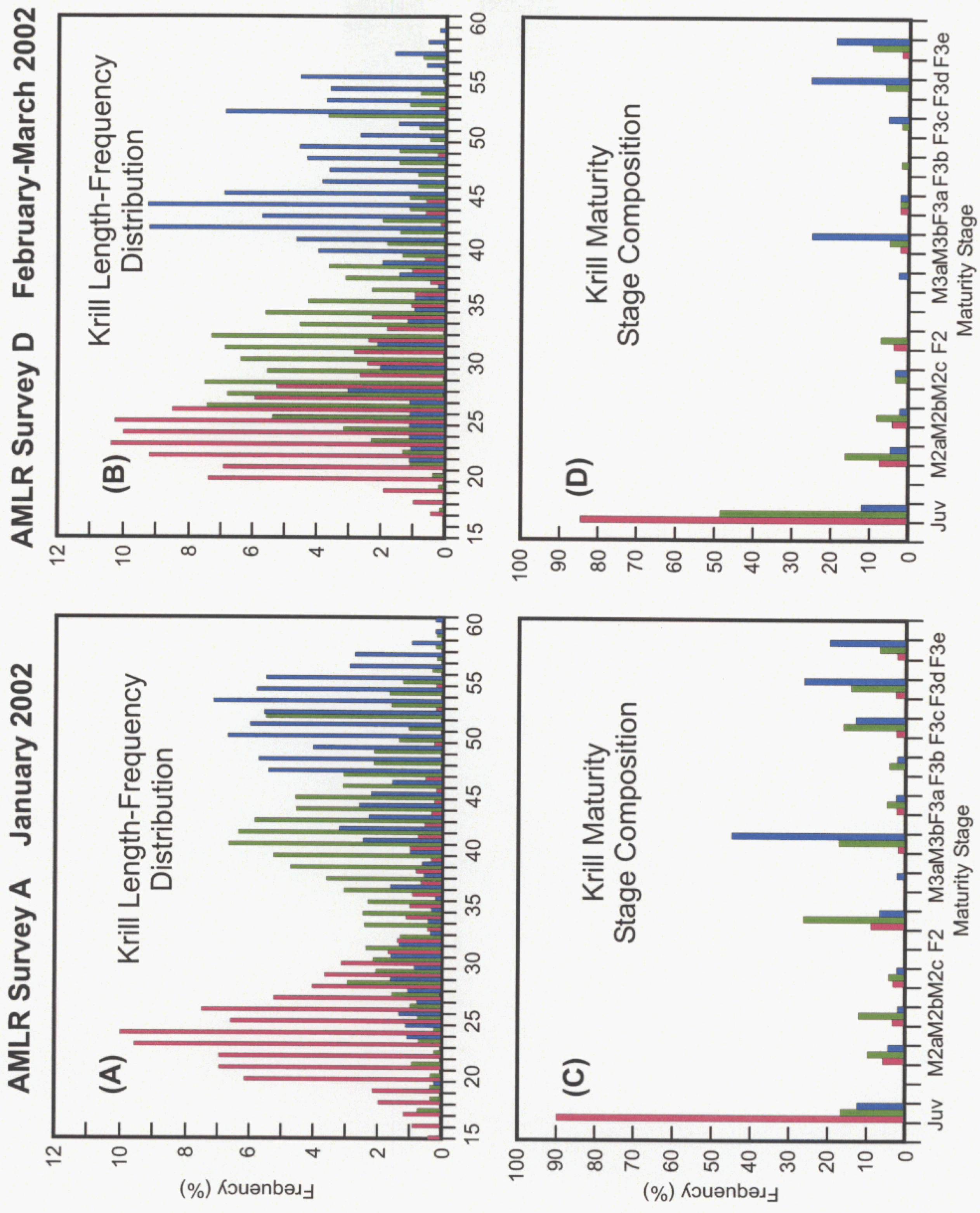


Figure 4.6. Length-frequency distribution and maturity stage composition of krill belonging to Clusters 1-3 during (A,B) Survey A and (C,D) Survey D.

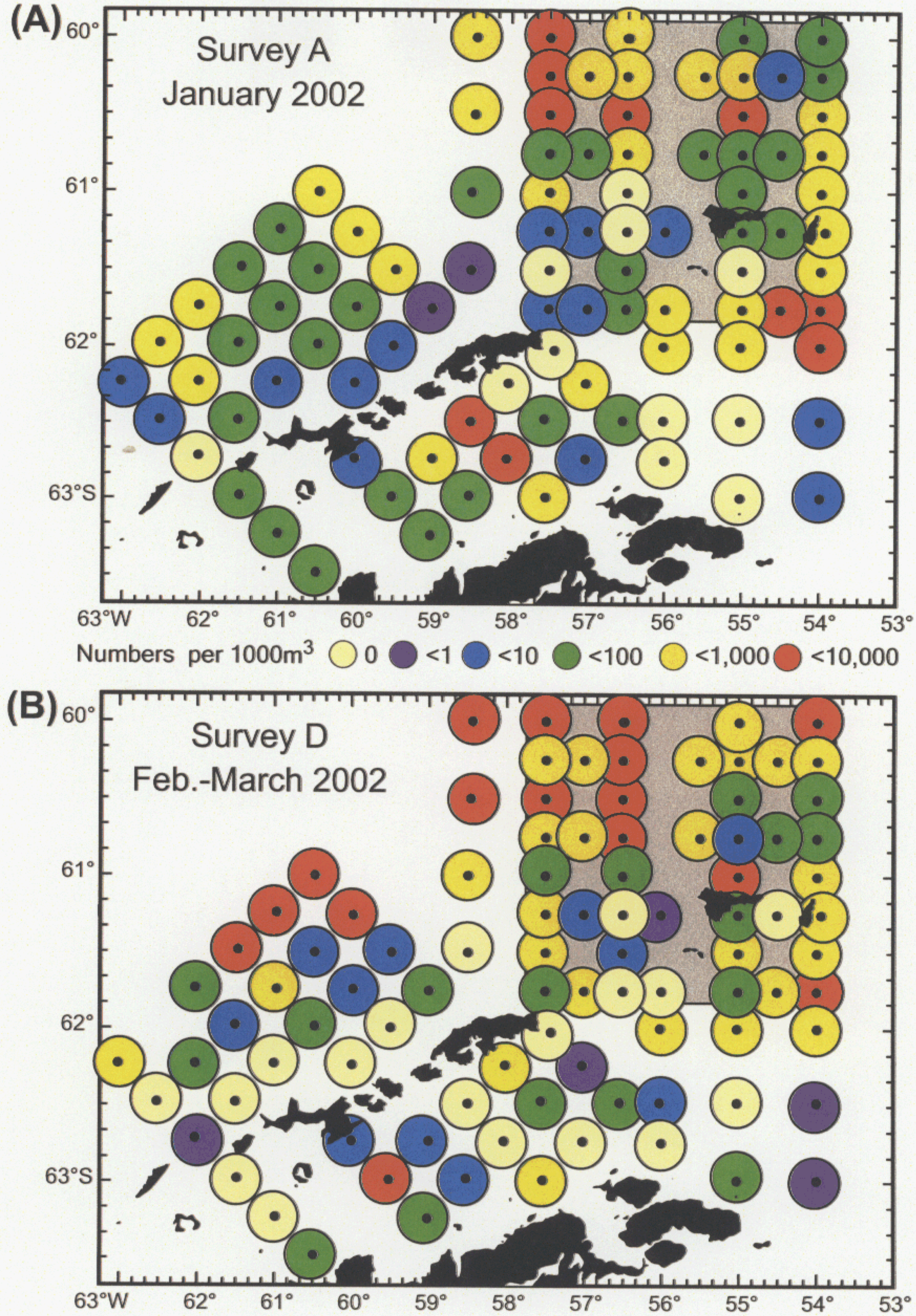


Figure 4.7. Distribution and abundance of *Salpa thompsoni* during (A) Survey A and (B) Survey D.

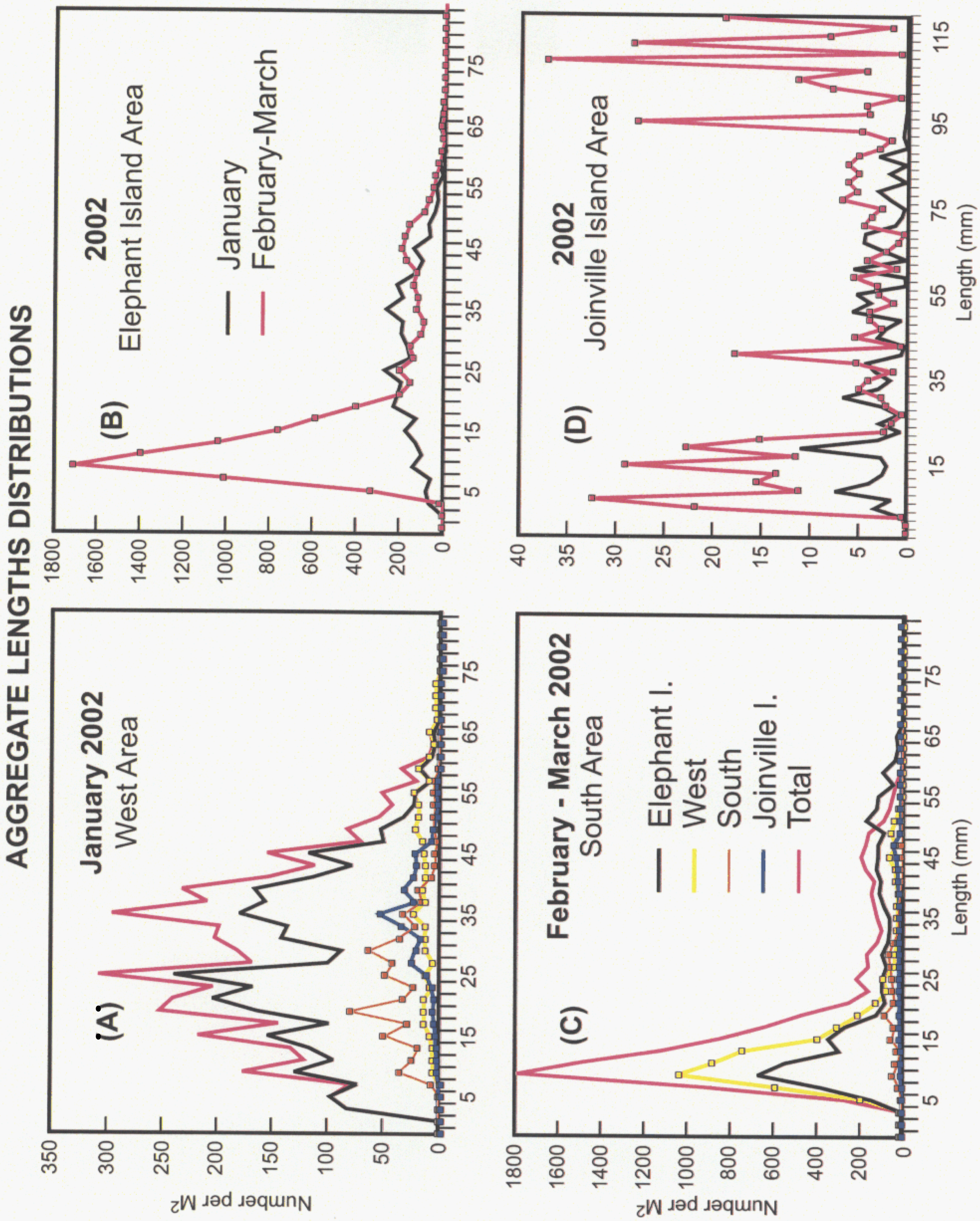


Figure 4.8. Length-frequency distributions of aggregate stage *Salpa thompsoni* in the large survey area and four subareas (A) January and, (B) February-March and seasonal differences in, (C) aggregate stage and (D) solitary stage length-frequency distributions, January-March 2002.

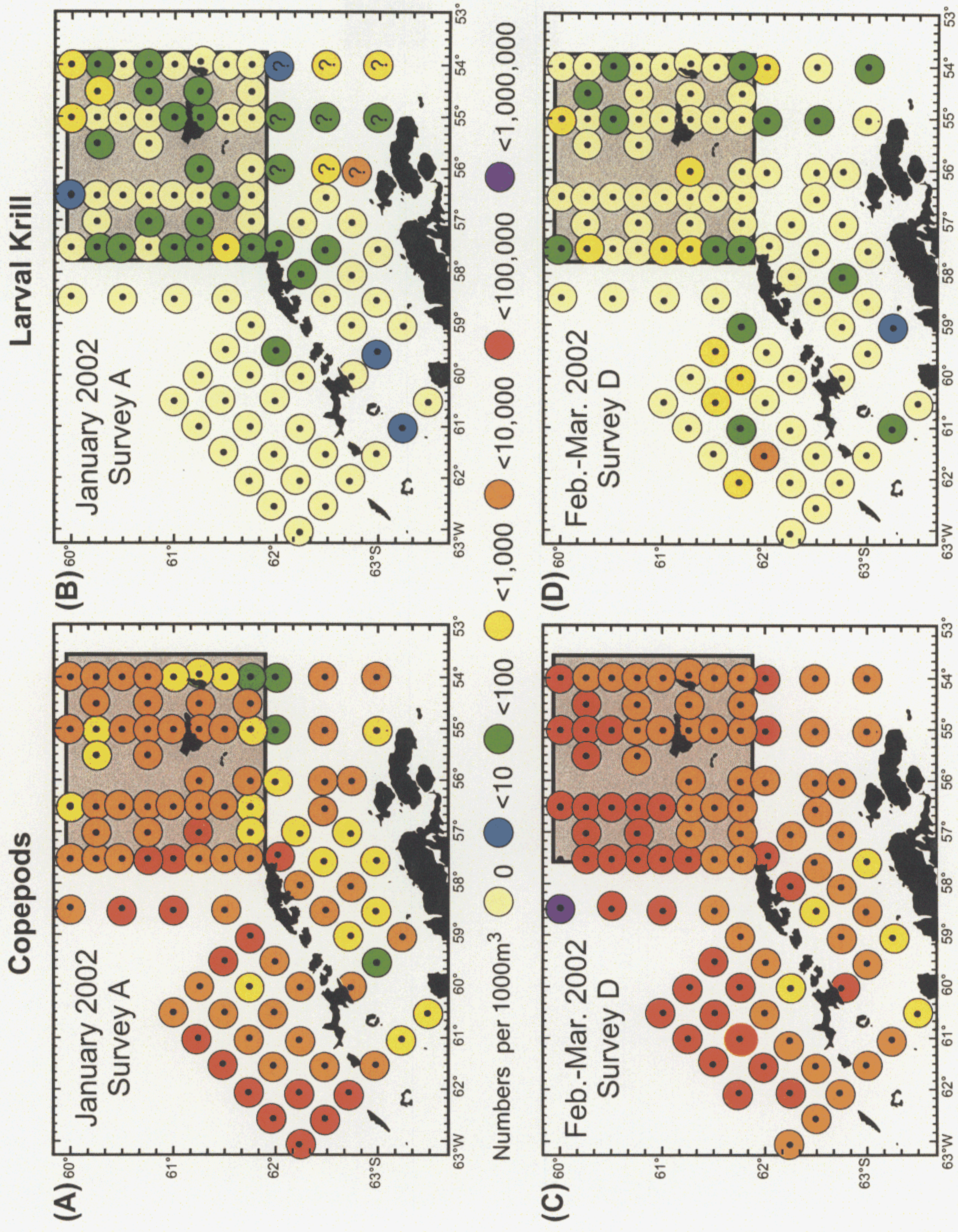


Figure 4.9. Distribution and abundance of copepods and larval krill in the (A,B) Survey A and (C,D) Survey D Areas.

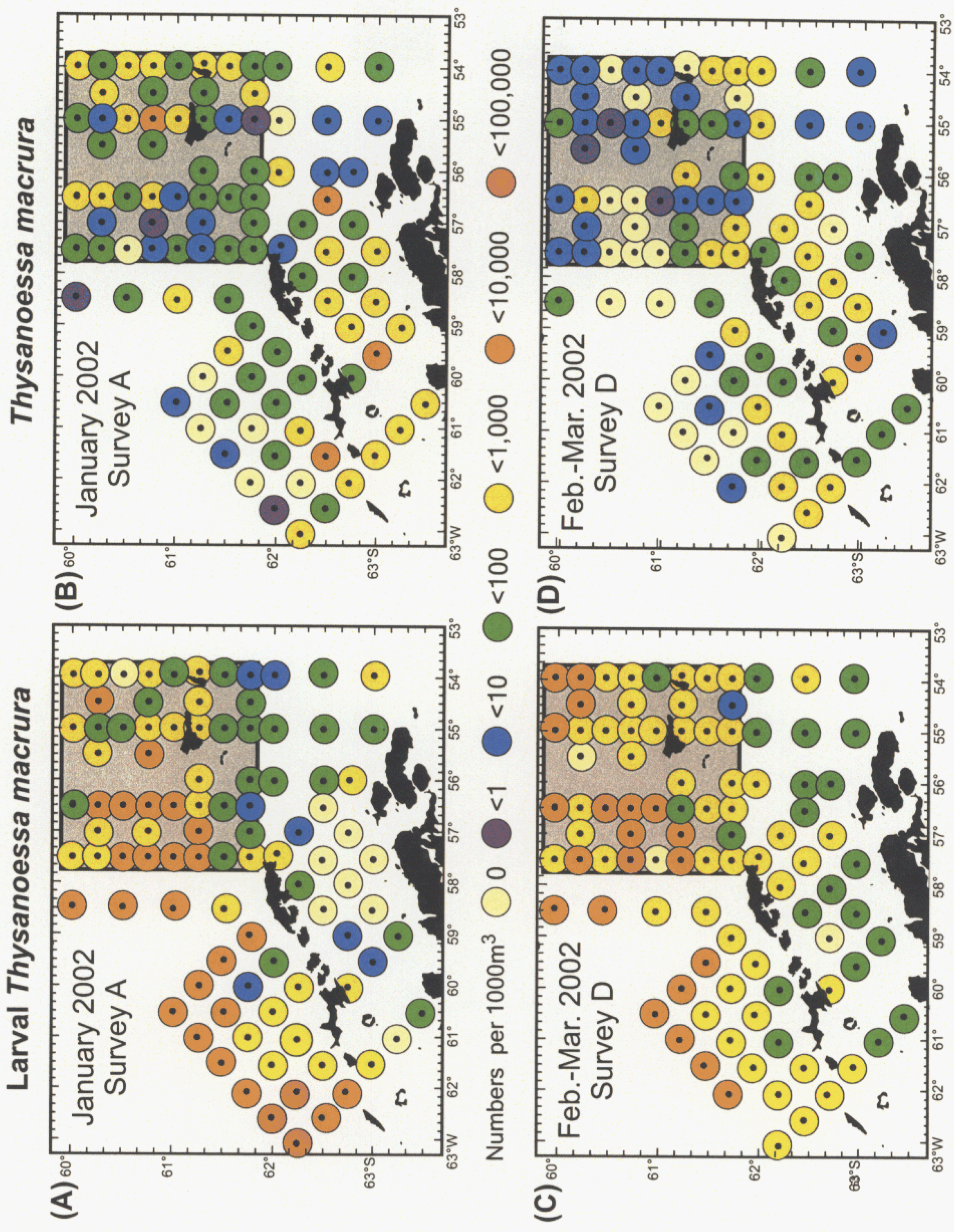


Figure 4.10. Distribution and abundance of larval and post larval *Thysanoessa macura* in the (A,B) Survey A and (C,D) Survey D Areas.

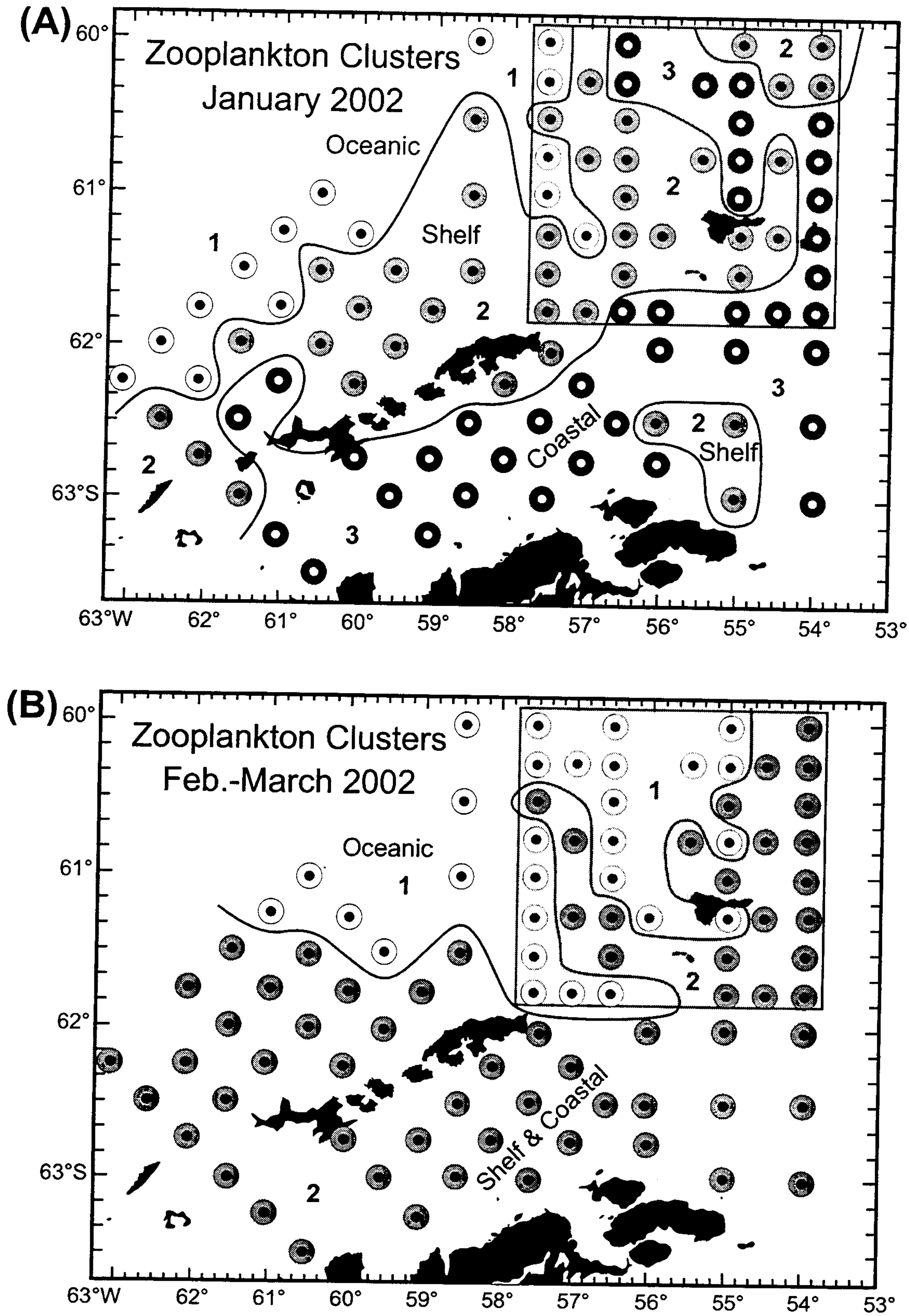


Figure 4.11. Distribution of three zooplankton assemblages (Clusters 1, 2 and 3) noted during the CCAMLR 2000 Survey. These roughly correspond to three "faunistic divisions" described by Mackintosh (1934): the eastern Scotia Sea (Cluster 1); Graham Land (Cluster 2); and transition belt (Cluster 3).

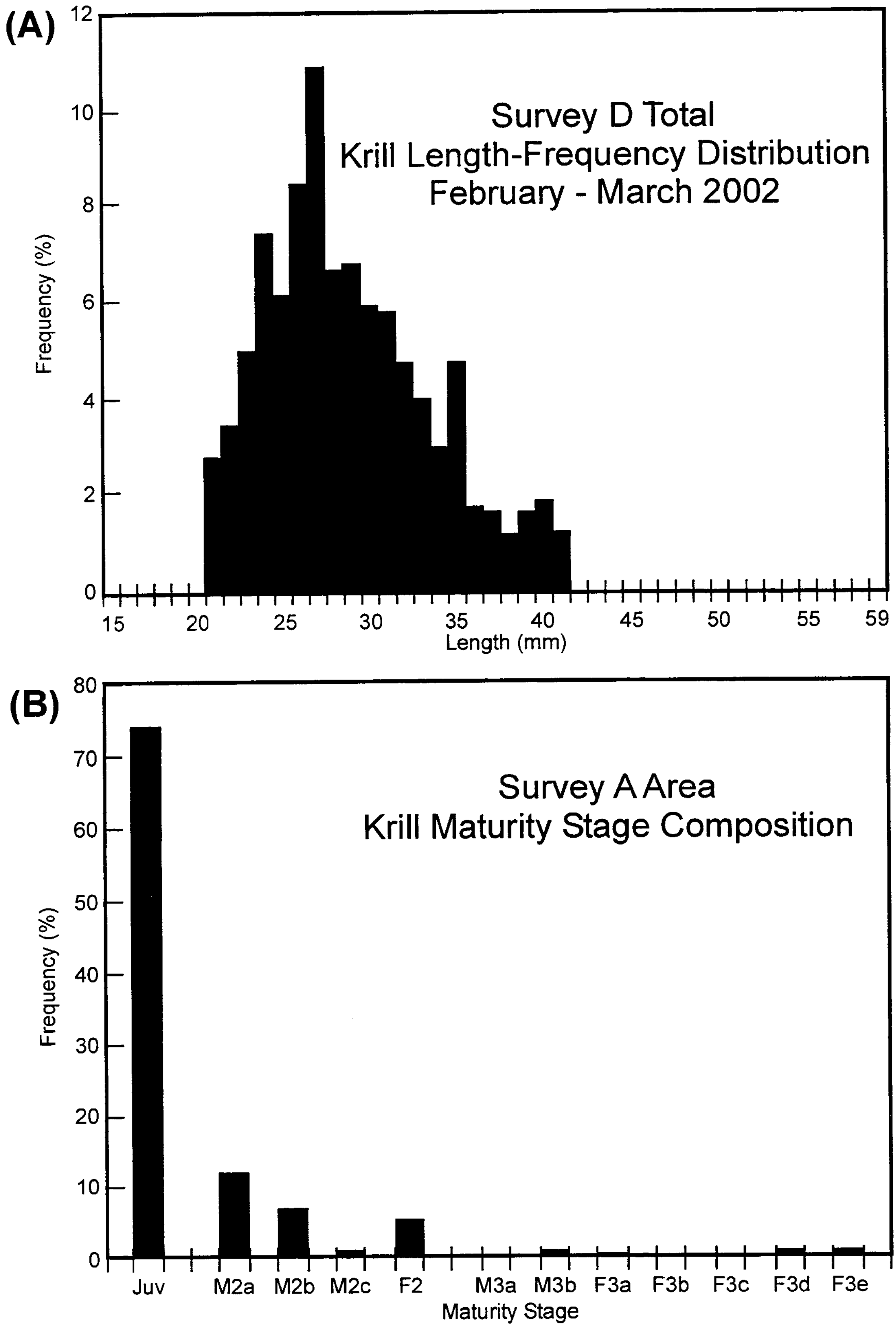


Figure 4.12. Krill (A) length-frequency distribution and (B) maturity stage composition during February-March Survey D.

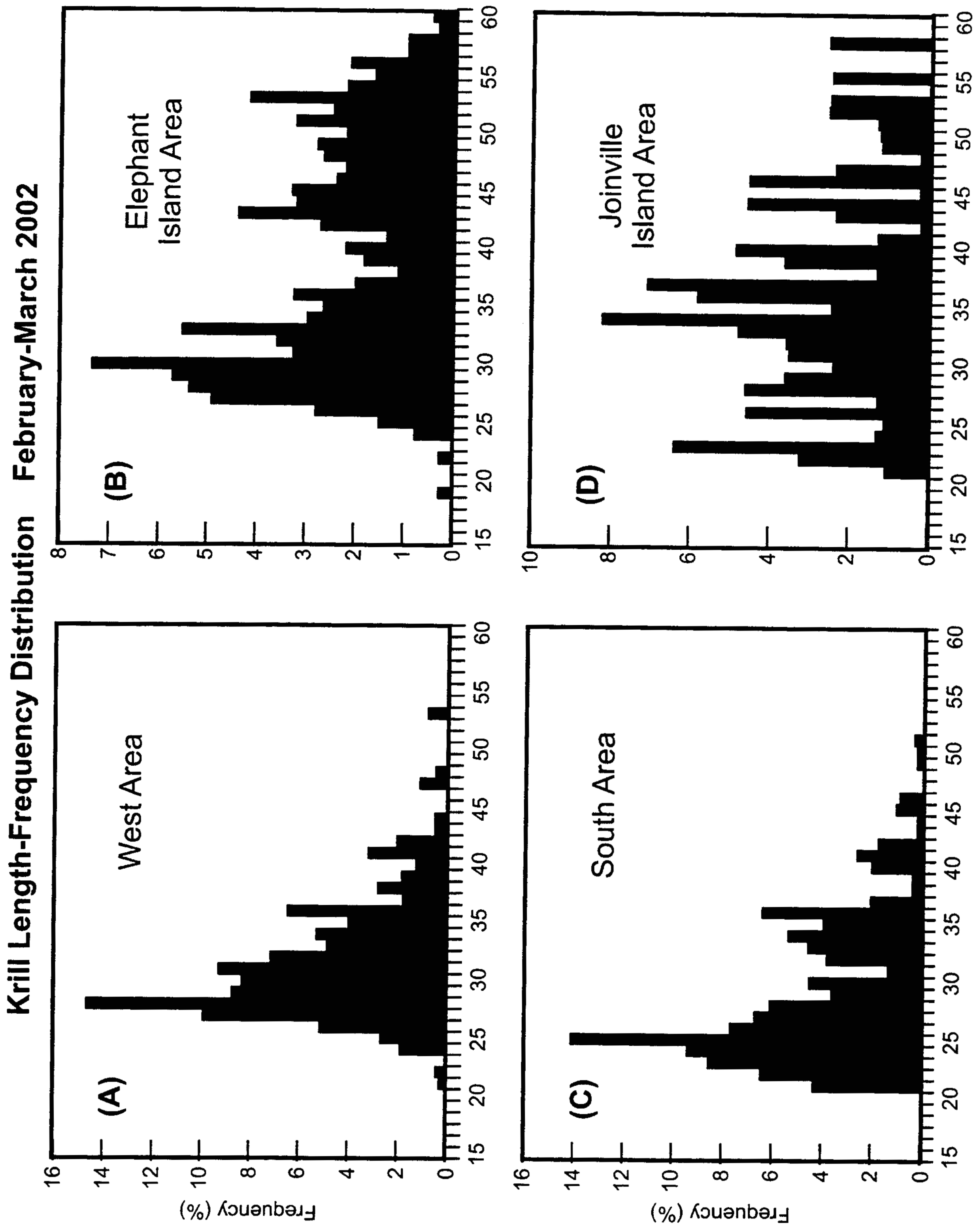


Figure 4.13. Length-frequency distribution of krill collected in the (A) West, (B) Elephant Island, (C) South and (D) Joinville Island Areas during February-March, 2002..

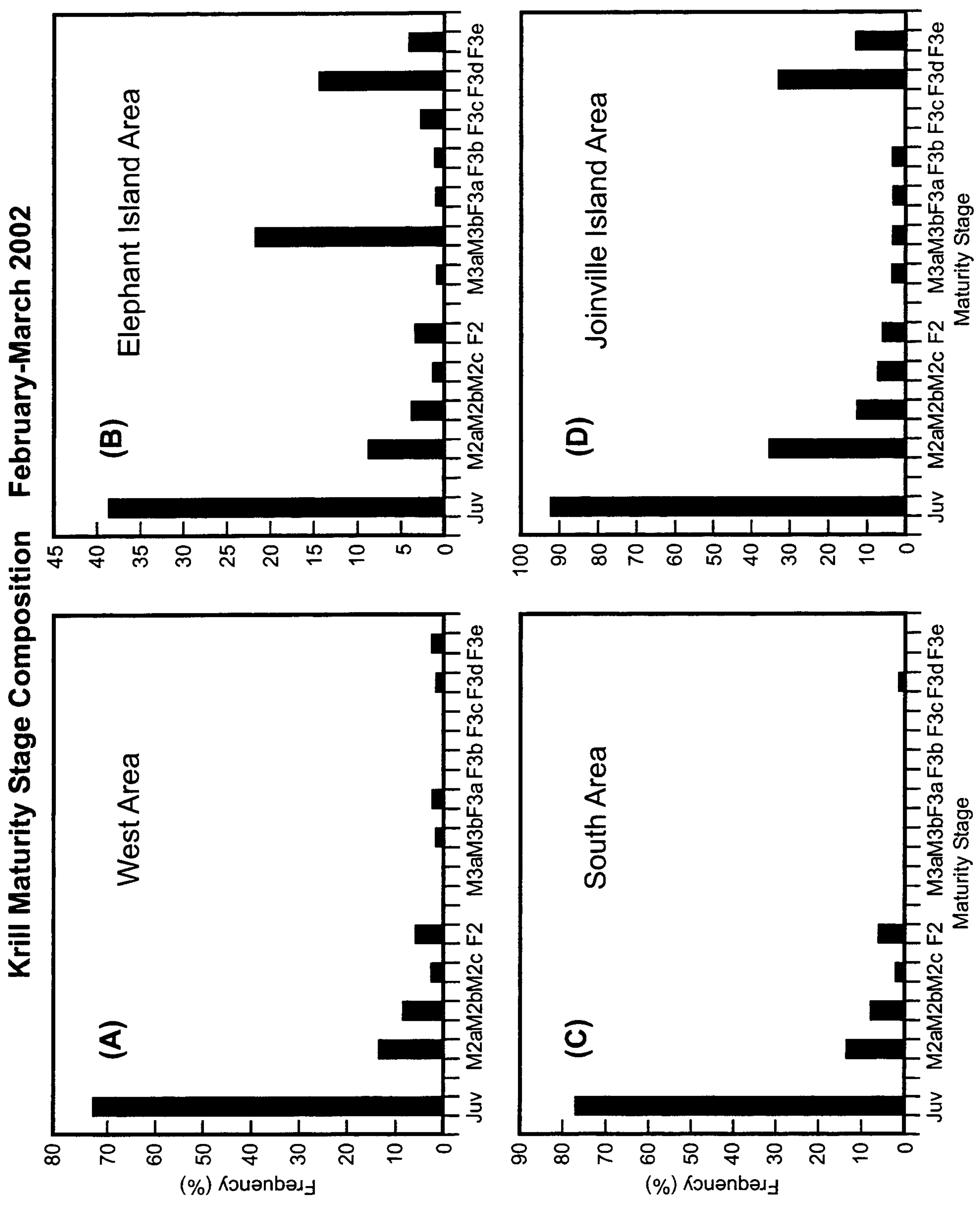


Figure 4.14. Maturity stage composition of krill collected in the (A) West Area, (B) Elephant Island, (C) South and (D) Joinville Island Areas February-March, 2002.

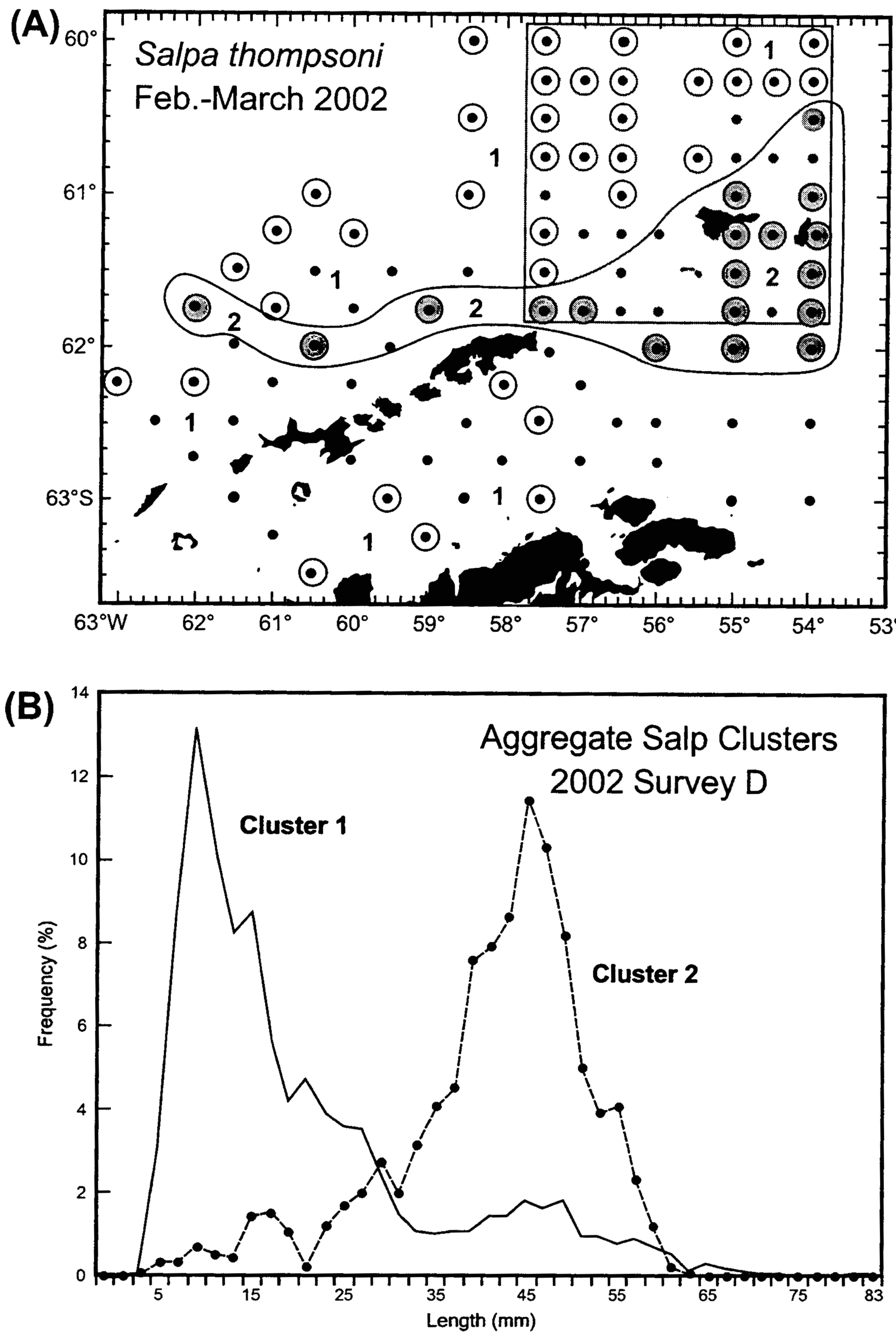


Figure 4.15. (A) Distribution and (B) length-frequency distribution of aggregate stage salps belonging to Clusters 1 and 2, February-March 2002.

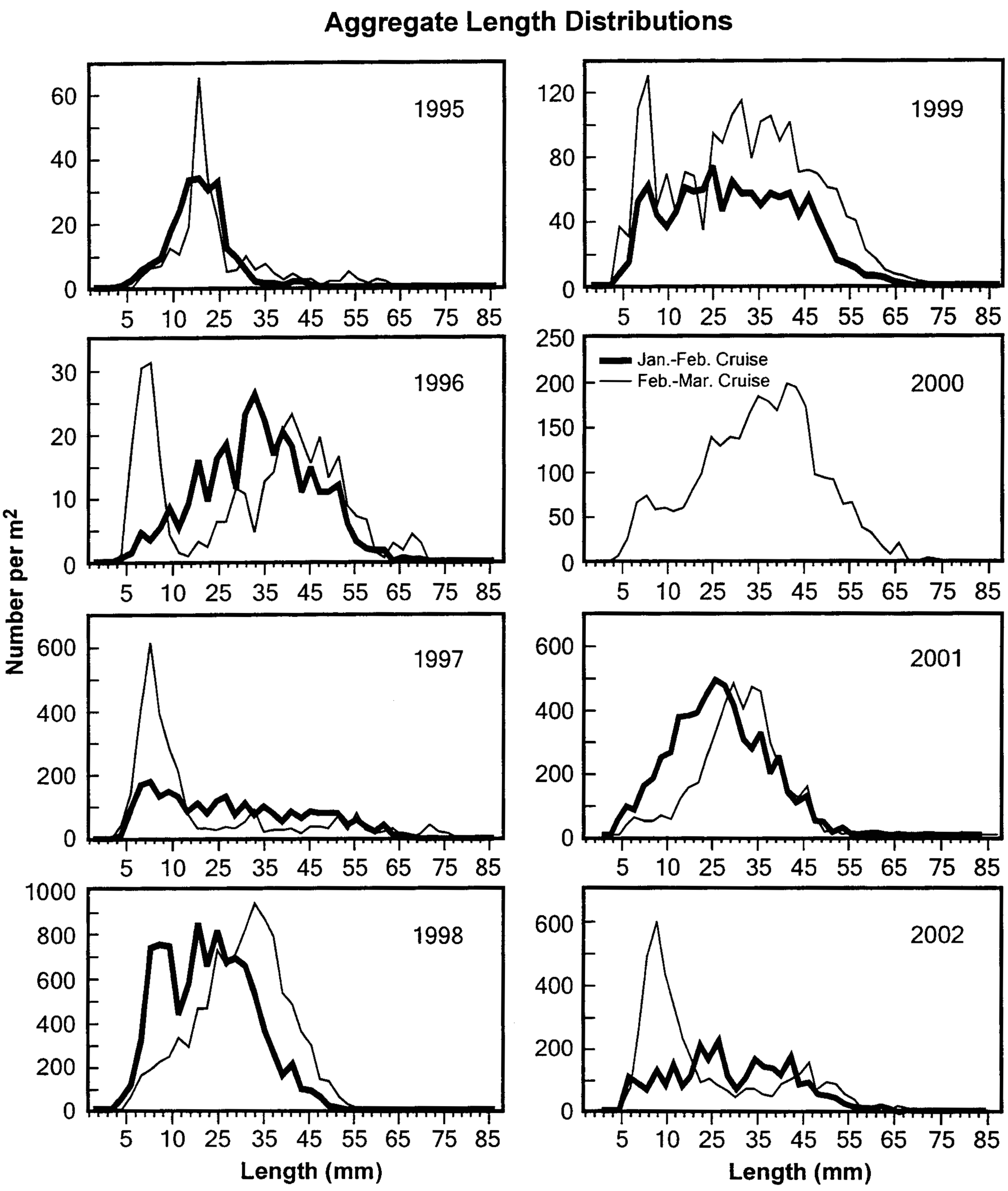


Figure 4.16. Salp length-frequency distribution during January-February and February-March, 1995-2002.

5. Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 2001-2002; submitted by Michael E. Goebel, John J. Lyons, Brian W. Parker, Jessica D. Lipsky, and Anne C. Allen.

5.1 Objectives: As upper trophic level predators, pinnipeds are a conspicuous component of some Antarctic marine ecosystems. They respond to spatio-temporal changes in the physical and biological oceanography of the environments that they live in and are directly dependent upon availability of krill (*Euphausia superba*) for maintenance, growth, and reproduction during the austral summer. Because of their current numbers and their pre-exploitation biomass in the Antarctic Peninsula region and Scotia Sea, Antarctic fur seals, are recognized to be an important "krill-dependent" upper trophic level predator. In its ecosystem approach to monitoring and management of Antarctic resources, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has established standardized protocol for monitoring fur seal duration of trips to sea and offspring growth. The general objectives for pinniped research are to monitor population demography and trends, reproductive success, and status of pinnipeds throughout the summer months. The Antarctic fur seal, *Arctocephalus gazella*, is the most abundant pinniped at Cape Shirreff and our studies are focused to a large degree on this species. Fur seals are currently in a recovery phase after over-exploitation by the fur trade in the 1800's. They are considered "krill-dependent predators" as krill are an important component of their diet during the breeding season. Thus our studies are focused on foraging ecology, diving, foraging range, energetics, diet, and reproductive success of fur seals rearing offspring.

Pinniped research was conducted by the U.S. AMLR Program at Cape Shirreff, Livingston Island, Antarctica (62°28'S, 60°46'W) during the 2001-2002 season. In addition to our annual studies at Cape Shirreff, a census of Antarctic fur seal pups at known fur seal colonies in the South Shetlands was also conducted from 30 January-5 February. Results of that census are reported in section seven of this report.

The 2001/02 field season began with the arrival at Cape Shirreff of a four person field team via the R/V *Nathaniel B. Palmer* on 14 November 2001. Research activities were initiated soon after and continued until closure of the camp on 10 March 2002. Our specific research objectives for the 2001/02 field season were to:

A. Monitor Antarctic fur seal female attendance behavior (time at sea foraging and time ashore attending a pup);

B. Monitor pup growth in cooperation with Chilean researchers collecting length, girth, and mass for fur seal pups every two weeks throughout the research period;

C. Document fur seal pup production at designated rookeries on Cape Shirreff and assist when necessary Chilean colleagues in censuses of fur seal pups for the entire Cape and the San Telmo Islands;

D. Collect and analyze fur seal scat contents on a weekly basis for diet studies;

E. Collect a milk sample at each adult female fur seal capture for fatty acid signature analysis and diet studies;

F. Deploy time-depth recorders on adult female fur seals for diving studies;

G. Record at-sea foraging locations for adult female fur seals using ARGOS satellite-linked transmitters (deployments to coincide with the U.S.-AMLR Oceanographic Survey cruises);

H. Tag fur seal pups for future demographic studies;

I. Re-sight animals tagged as pups in previous years for population demography studies;

J. Monitor survival and natality of the tagged adult female population of fur seals;

K. Extract a lower post-canine tooth from adult female fur seals for aging studies;

L. Deploy a weather station for continuous recording of wind speed, wind direction, ambient temperature, humidity and barometric pressure during the study period; and

M. Record other tagged pinnipeds observed and any pinnipeds carrying marine debris (i.e. entanglements).

5.2 Accomplishments:

A. Female Fur Seal Attendance Behavior: Lactation in Otariid females is characterized by a cyclical series of trips to sea and visits to shore (attendance) to suckle their offspring. These cycles are commonly referred to as attendance patterns. Measuring changes in attendance patterns (especially the duration of trips to sea) of lactating Otariids is one of the standard indicators of a change in the foraging environment and availability of prey resources. Generally, the shorter the duration of trips to sea, the more resources a female can deliver to her pup during the period from birth to weaning.

We instrumented 28 lactating females from 5-12 December 2001. The study was conducted according to CCAMLR protocol (CCAMLR Standard Method C1.2 Procedure A) using VHF radio transmitters (Advanced Telemetry Systems, Inc., Model 7PN with a pulse rate of 40ppm). Standard Method C1.2 calls for monitoring of trip durations for the first six trips to sea. Presence or absence on shore was monitored for each female every 30 minutes for 30 seconds. All females were instrumented 1-2 days post-partum (determined by the presence of a newborn with an umbilicus) and were left undisturbed for at least their first six trips to sea. Pups were captured at the same time as their mothers, and were weighed, measured, and marked with an identifying bleach mark. The general health and condition of the pups were monitored throughout the study by making daily visual observations. The presence/absence was recorded for each female for the first six trips to sea.

The first female in our study to begin her foraging cycles did so on 10 December and last female to complete six trips to sea did so on 24 January. The mean trip duration for the combined first six trips to sea this year was 3.18 days (±1.21, N=166, range: 0.50-7.85) the second lowest mean since data collection began at Cape Shirreff in 1997/98 (Table 5.1, Figure 5.1; ANOVA, $df_{4,833}$, p<0.005). Mean trip duration was longer than last year (**00/01:** 2.71d ±0.83, N=168, range: 0.75-5.66; Bonferroni p=0.01) but not different from 1999/00 (**99/00:** 3.47d ±1.00, N=138, range: 0.60-8.25; Bonferroni p=0.53).

Mean duration for the first six, non-perinatal visits was 1.55 days (±0.62, N=166, range: 0.19-4.84) (Table 5.1, Figure 5.1; ANOVA, $df_{4,832}$, p<0.005). There was no difference in visit durations from 1999/00 (Bonferroni p=0.09) and 2000/01 (Bonferroni p=0.28). However, visit durations were longer than in 1998/99 (Bonferroni p=0.01) and 1999/00 (Bonferroni p=0.002).

The distribution of trip durations was skewed to longer trips in four (1999/00-2001/02) of the past five years (Table 5.1, Figure 5.2 for the last two years). Visit durations for all four years were likewise skewed (Table 5.1).

There was no difference in the postpartum mass of our attendance females from 1998/99 to 2001/02 (ANOVA, $df_{3,111}$, p=0.84). Females in the last four years were, however, larger than females in 1997/98, the first year of our studies (Figure 5.3a; ANOVA, $df_{4,142}$, p<0.0001; **97/98:** Mean=39.2kg ρ5.76, N=31; **98/99:** Mean=45.6kg ρ6.67, N=32; **99/00:** Mean=46.5kg ρ5.90, N=23; **00/01:** Mean=46.3kg ρ4.52, N=28; **01/02:** 45.2kg ρ7.32, N=28). This is because females in that year were sampled later (21-31 December) and late arriving females tend to be younger and smaller. The mass-to-length ratio, perhaps a better measure of condition, for all five years was not different (Figure 5.3b; ANOVA, $df_{4,142}$, p=0.79; **97/98:** Mean=0.338 ρ0.033, N=31; **98/99:** Mean=0.347 ρ0.041, N=32; **99/00:** Mean=0.346 ρ0.034, N=23; **00/01:** Mean=0.35kg ρ0.026, N=28).

B. Fur Seal Pup Growth: Measures of fur seal pup growth were a collaborative effort between the U.S. research team and Chilean researchers. Data on pup weights and measures were collected every two weeks beginning on 16 December and ending 1 March (six bi-weekly samples). Data were collected as directed in CCAMLR Standard Method C2.2 Procedure B. The results will be submitted to CCAMLR by Chilean researchers.

C. Fur Seal Pup Production: Fur seal pups (live and dead) and females were counted by U.S. researchers at four main breeding beaches (Copihue, Maderas, Cachorros, and Chungungo) on the east side of the Cape. Censuses were conducted every other day from 18 November 2001 through 10 January 2002. The maximum number counted (live and cumulative dead) at the combined four beaches in 2001/02 was 2435 on 6 January 2002 (Figure 5.4), an 8.3% increase over the maximum count for the same sites last year (**00/01:** 2,248 on 29 December 2000; **99/00:** 2,104 on 3 January 2000). The maximum count was taken as the mean of six separate counts of live pups (three each for two counters) on 6 January 2002 with the addition of total cumulative dead for that date (136 pups). There was a 0.7% difference in the mean count between observers (counter 1: mean=2291 pups, s.e.=6.6; counter 2: mean=2306 pups, s.e.=31.5).

The median date of pup births was 7 December, one day earlier than last year and the year before (99/00-00/01: 8 Dec) and three days earlier than first two years of our studies at Cape Shirreff (97/98-98/99: 10 Dec). Thus it appears that there is a trend for earlier parturition over the last five years. This may be due to earlier arrival of pregnant females or to fewer late-arriving females, which tend to be younger females (e.g. if recruitment of primiparous females were lower). The fact that pup production has increased on our study beaches over the same period would suggest that lower recruitment is not responsible for the earlier median date of parturition but rather earlier arrival is the reason.

D. Diet Studies: Information on fur seal diet was collected using three different sampling methods: collection of scats, enemas, and fatty acid signature analysis of milk. In addition to scats and enemas, an occasional regurgitation is found in female suckling areas. Regurgitations often provide whole prey that is only minimally digested. Scats are collected from around suckling sites of females or from captured animals that defecate while captive. All females that are captured to remove a time-depth recorder or satellite-linked transmitter (PTT) are given an enema to collect fecal material containing dietary information. In addition to diet information from captive animals, ten scats were collected opportunistically from female suckling sites every week beginning 20 December. The weekly scat sample is collected by systematically walking transects of female suckling areas and collecting any fresh scats within a short range of the observer. This method prevents any bias associated with the difference in visibility between krill laden scats, which are bright pink, and fish laden scats, which are gray to brown, and blend in with the substrate more easily.

In total, we collected and processed 103 scats, six enemas, and six regurgitations from 26 December 2001-28 February 2002. Diet samples that could not be processed within 24 hours of collection were frozen. All samples were processed by 8 March. Up to 30 krill carapaces were measured from each sample that contained krill. Otoliths were sorted, dried, identified to species and measured for length and width. The number of squid beaks were counted and preserved in 70% alcohol for later identification. A total of 2827 krill carapaces were measured. Most of these (87.4%) were from weekly scat collections; 94.2% (97 of 103) of the weekly scat samples collected contained krill. In addition, 4,546 otoliths from three species of myctophid fish were collected from 84.5% of the weekly scat collections (*Electrona antarctica*, n=1433; *Electrona carlsbergi*, n=875; *Gymnoscopelus nicholsi*, n=2238; plus an additional 390 unidentified otoliths). A total of 80 squid beaks (*Brachioteuthis picta*) were collected from 13.6% of the weekly samples.

The proportions of krill, fish and squid were different every year (Table 5.2, X^2=30.8, d.f.=6, $p<0.0005$). Results indicated more fish in the diet in December than in previous years (Figure 5.5). The December increase was primarily an increase in *Electrona antarctica* and *Electrona carlsbergi* and not in *Gymnoscopelus nicholsi* (Figure 5.6). The weekly proportions of the three most common fish species in fur seal diets at Cape Shirreff varied throughout our ten-week scat collection period. *E. antarctica* occurred in fur seal diets with a bimodal distribution (Figure 5.6) with peaks at week one (26 Dec-1 Jan) and week four (16-22 Jan) of collections. *E. carlsbergi* was most abundant week two (2-8 Jan). *Gymnoscopelus nicholsi* had very little occurrence in the diet until week five (23-29 Jan) and also had a bimodal distribution of occurrence (Figure 5.6). Squid was more common in the diet and, as in previous years, squid was confined primarily to scats collected in February (Figure 5.6).

The length and width of krill carapaces found in fur seal scats were measured in order to determine length distribution of krill consumed. Up to thirty carapaces from each scat were randomly selected and measured according to Hill (1990). The following linear discriminant function (Reid and Measures 1998) was applied to the carapace length (CL) and width (CW) to determine sex of individual krill:

$$D = -1.04 - 0.146(CL) + 0.265(CW)$$

Positive discriminant function values were identified as female and negative values male. Once the sex for each krill was determined the following regression equations from Reid and Measures (1998) were applied to calculate total length (TL) from the carapace length:

$$\text{Females: } TL = 15.3 + 2.09(CL)$$
$$\text{Males: } TL = 13.9 + 2.29(CL)$$

A total of 2,827 carapaces were measured from 111 scats, enemas, and regurgitations in 2001/02. Summary statistics are presented in Table 5.3. Data from 1999/00 and 2000/01 are also presented for comparison. Krill consumed by fur seals in 2001/02 was on average smaller than in 2000/01 (Table 5.3; ANOVA, $d.f._{2,8291}$, F-ratio = 430.6, $p<0.0005$). The length distributions (in 2mm increments) for the last three years are presented in Figure 5.7. Smaller krill (<50mm) began appearing in fur seal scats in late January and by March krill in fur seal diets had a strongly bimodal length distribution (Figure 5.8).

E. Fatty Acid Signature Analysis of Milk: In addition to scats, enemas, and regurgitations, we collected 119 milk samples from 79 female fur seals. Each time a female was captured (either to instrument or to remove instruments), 30mL of milk was collected by manual expression. Prior to collection of the milk sample, an intra-muscular injection of oxytocin (0.25mL, 10 UI/mL) was administered. Milk was returned (within several hours) to the lab where two 0.25mL aliquots were collected and each stored in a solvent-rinsed glass tube with 2mL of chloroform with 0.01% butylated hydroxytoluene (BHT, an antioxidant). Samples were flushed with nitrogen, sealed, and stored frozen until later extraction of lipid and trans-esterification of fatty acids. Of the 119 samples, 24 were collected from perinatal females and 24 were collected from 16 females that had dive data for the foraging trip prior to milk collection.

F. Diving Studies: Eleven of our 28 females transmittered for attendance studies also received a time-depth recorder (TDR, Wildlife Computers Inc., Mark 7, 8.6 x 1.9 x 1.1cm, 27g) on their first visit to shore. All of them carried their TDR for at least their first six trips to sea. One of the 11 TDRs failed, thus only 10 records were collected for dive data for the first six trips to sea. In addition, all other females captured for studies of at-sea foraging locations also received a TDR. The total number of females with diving data for 2001/02 was 16. The total number of trips recorded on TDRs from 10 December 2001 – 16 February 2002 was 104.

G. Adult Female Foraging Locations: We instrumented 13 females with satellite-linked transmitters (ARGOS-linked Platform Terminal Transmitters or PTTs) from 24 December – 16 February. The number of females with PTTs was fewer than in previous years because of four PTTs that failed bench checks before deployment. Eight of the 13 were deployed to coincide with the U.S.-AMLR large-scale oceanographic survey. All 13 females carried a PTT for at least two trips to sea, 10 for three trips and one female, because she had numerous short trips to sea carried her PTT for six trips. Results of fur seal foraging location data analysis and interannual comparisons are pending.

H-J. Demography and Tagging: Together Chilean and U.S. researchers tagged 499 fur seal pups (262 females, 237 males) from 21 January – 7 March 2002. All tags placed at Cape Shirreff were Dalton Jumbo Roto tags with white tops and orange bottoms. Each pup was tagged on both fore-flippers with identical numbers (2501-2999). Tag 3000 was misprinted 2000 and not deployed. Most pups (388 or 77.8%) were tagged on the east side of the Cape from Playa Marko to Chungungo beach. A total of 111 pups (58 females, 53 males) were tagged at Loberia beach on the northwest side of the Cape.

In addition to the 499 pups tagged, we also tagged 37 adult lactating, previously untagged, females (231-264, 266, 267, 271) and three females that had previously been tagged (i.e. females 122, 053, and 638 had their tags replaced with 265, 270, and 272, respectively). All tags were placed on females with parturition sites on east side beaches (Copihue, Maderas, Cachorros, and Chungungo beaches).

Last year we added 34 adult females to our tagged population. These 34, when added to the females that returned in the previous season (n=161), gave an expected known tagged population of 195 for 2001/02 (Table 5.4). Of these, 191 (97.9%) returned in 2001/02 to Cape Shirreff and 174 (91.1%) returned pregnant (Figure 5.9). The return and pregnancy rates were the highest recorded in four seasons of adult female tag returns (Return rates: **98/99:** 83.8%, **99/00:** 94.0%, **00/01:** 90.2; Natality rates: **98/99:** 75.7%, **99/00:** 86.7%, **00/01:** 78.6; Figure 5.9).

Our tagged population of females returned (on average) two days earlier than last year. In 2000/01, the mean date of pupping for tagged females (which had a pup in both years) was 7 December (ρ6.96, N=139) and in 2001/02, for the same females, it was 5 December (ρ6.37, N=139). The median date of pupping for our tagged females for 2000/01 was 7 December and for 2001/02 it was 4 December. This result is earlier for both years than our estimates of the median date of pupping based upon pup counts for the season (see section C above). It suggests that our tagged population is slightly biased towards earlier arriving (and likely older) females. More importantly, however, is that both measures show a trend for an earlier date of parturition for Cape Shirreff fur seals.

This year we refined our tag re-sight protocol to enable us to better measure effort from year to year. The new protocol now requires systematic searches of defined sub-areas while "on the clock" and all tags observed are now recorded as systematic or opportunistic (tags observed while performing other research activities).

In 2001/02 we observed only seven yearlings (three females and four males that were tagged as pups in 2000/01; Table 5.5). This represents a much lower rate of return for yearlings than sighted last year (2000/01: 26 yearlings sighted from the 1999/00 cohort). Table 5.5 presents observed tag returns for four cohorts in their first year. Tag deployment, the total number placed and re-sighting effort for all four cohorts were similar and the variance is likely due to differences in the post-weaning physical and/or biological environment. The differences in return rates are not necessarily due to survival but may be due to other factors (e.g. physical oceanography of the region, over-winter prey availability or other factors) that influence whether animals return to natal rookeries in their first year.

We calculated the minimum percent survival for year one based upon tag re-sights for the first two years following tagging (Table 5.6). The survival values are adjusted based upon the probability that an individual would lose both tags. Tag loss (right or left) was assumed to be independent. The results presented are for the minimum percent survival because animals return for the first time to natal rookeries at different ages and the probability of returning at age 1, age 2, etc. may vary for different cohorts. Given similar re-sighting effort the three cohorts presented have return rates in the first two years that are very different (Figure 5.10). Most notable is that the 1999/00 cohort appears exceptional in its rate of return in both its first year and its second. The minimum survival to age-1 for the 1999/00 cohort was 25.0%. If the transition to nutritional independence and foraging conditions their first winter are critical to juvenile otariid survival (as suggested by York, 1994), then 1999/00 cohort experienced exceptionally good conditions at weaning and for their first winter at sea. The observed cohort differences are important whether due to survival or differences in dispersal that result in a different rate of return.

K. Tooth Extraction and Age Determination: We began an effort of tooth extraction from adult female fur seals for age determination in 1999/00. Tooth extractions are made using gas anesthesia (isoflurane, 2.5-5.0%), oxygen (4-10 liters/min), and midazolam hydrochloride (1cc). A detailed description of the procedure was presented in the 1999/00 annual report.

This year, from 16-29 January, we took a single post-canine tooth from 60 previously tagged females and 10 juvenile female fur seals. Two of the adult tagged females were tagged as pups at Seal Island and four of the juveniles were tagged as pups on Cape Shirreff. The teeth collected from these seven females will be used for validation of the aging technique. Females ranged in size from a mass of 28.6-55.2kg and length of 115-143cm. The mean total time captive was 14.0 min (ρ4.0) and the mean total time under anesthesia was 11.0 min (ρ 4.0, n=70). The time captive and the time under anesthesia both decreased over last year (18.0 and 14.0 min, respectively). The decreases were likely due to a more experienced crew.

Tooth extraction is the most invasive of our research techniques and could potentially affect reproductive success. We therefore have focused considerable effort in measuring the effects of extracting a tooth on attendance behavior (i.e. trip and visit durations), diving behavior, return and natality rate in the year following tooth extraction. Last year we reported some of our preliminary results, which showed no adverse affect on survival, natality, or subsequent trip durations. We compared return and natality of the first 79 females to have a tooth extracted to 94 females that did not. Females that had a tooth extracted in 1999/00 had a slightly lower rate of return (0.5% lower) and natality (2.3% lower) in 2000/01 than did females that did not have a tooth extracted (Percent return: 90.4 vs. 89.9; Natality: 88.2 vs. 85.9%). The differences were not significant (Return: X^2=0.015, d.f.=1, P=0.90; Natality: X^2=0.186, d.f.=1, P=0.67). This year females that had a tooth extracted last year (N=60) had higher return and natality rates than females that did not have a tooth extracted (N=131) (Percent return: 98.0 vs. 92.4%; Natality: 97.0 vs. 87.6%). The higher rates are likely due to the fact that we only extracted teeth last year from tagged females, whereas the year before 50% of the females that had a tooth extracted were previously untagged. Tagged females are more likely to be older than randomly selected untagged females in February (the month we collected teeth in 1999/00). Monitoring of return and natality for females that have had a tooth extracted will continue in the future to determine if the difference is statistically significant.

L. Weather at Cape Shirreff: A weather data recorder (Davis Weather Monitor II) was set up at the U.S.-AMLR field camp at Cape Shirreff from 18 November 2001 to 6 March 2002. The recorder archived wind speed and direction, barometric pressure, temperature, humidity, and rainfall at 15-minute intervals. The sampling rate for wind speed, temperature, and humidity was every eight seconds; the averaged value for each 15-minute interval was stored in memory. Barometric pressure was measured once at each 15-minute interval and stored. When wind speed was greater than 0, the wind direction for each 8-second interval was stored in one of 16 bins corresponding to the 16 compass points. At the end of the 15-minute archive interval, the most frequent wind direction was stored in memory.

Mean daily temperature at Cape Shirreff was (on average) 0.47θC warmer this year than in 2000/01 for the same time period (18 November-12 February). Mean temperature from 18 November 2001 to 6 March 2002 was 2.36θC $\pm$ 1.59 (N=10,240). Wind speed for the same time period was 15.7 km/hr $\pm$ 8.3 with a maximum gust to 72.0 km/hr on 14 December. Total measurable precipitation in 2001/02 was greater than previous years 2000/01 but with similar total number of days of measurable precipitation for the time period 21 December-24 February (**1998/99:** 59.6mm for 43 days, **1999/00:** 57.1mm for 35 days, **2000/01:** 56.0mm for 36 days, **2001/02:** 80.0mm for 43 days). Over-winter snow cover at the start of this season was considerably less than last year though we do not have a precise measure of this. We also do not know how much the diminished snow cover was due to lower over-winter accumulation and how much to an early thaw. The thaw was earlier this year. By the time fur seal pupping began in late November most of the snow had melted from breeding areas, as well as, in extensive areas behind breeding beaches. The reduced snow cover at the time of breeding had a pronounced affect on distribution of fur seals early in the season. Female fur seals tended to pup over a larger area and above the beaches more than in years with more snow cover.

M. Miscellaneous: Tagged Elephant Seals. We observed three tagged elephant seals in 2001/02. All three had plastic Dalton jumbo roto tags and were tagged at Sea Lion Island, Falkland Islands (Galimberti, pers. com.). Tag number, color, right or left rear flipper, age/sex class, and date of observation at Cape Shirreff were as follows:

A06 (yellow, left)/ A29 (yellow, right), adult female, 12 Feb 2002
Z05 (yellow, left)/ W17 (white, right), adult female (also dye marked: MANO on each side), 2 Feb 2002
F82 (orange, left), adult female, 9 Jan 2002

Entangled pinnipeds. We observed only one entangled juvenile male fur seal this season. The entanglement debris, a single nylon string was removed.

5.3 Preliminary Conclusions: The 2001/02 season was better for Antarctic fur seals by several measures than the 1997/98-1999/00 seasons. It was similar in some respects to last year but mean foraging trip duration for lactating females was slightly longer than in 2000/01. Fur seal pup production at U.S.-AMLR study beaches on Cape Shirreff increased by 8.3% over last year. The median date of pupping based on pup counts was one day earlier than the last two years and three days earlier than in 1997/98 and 1998/99. The mean arrival and parturition dates for our tagged female population was also two days earlier than last year. Over winter survival and return rates for adult females were higher than any previous year, at 97.9%. There was no change in arrival condition compared to previous years. Natality rates were also higher than in previous years (91.1%). Return rate for yearlings was low (1.4%) and comparable to that of the 1998/99 cohort (1.2%). The 1999/00 cohort, however, appears to be an exceptionally strong cohort (5.2% return as yearlings and 25% minimum percent survival for the first year based on two years of sighting data). The mean trip duration for adult females' first 6 trips to sea was slightly greater than last year (3.18 vs. 2.71 days) but still less than from 1997/98 to 1999/00 (4.19, 4.65, and 3.47 days, respectively). Fur seals this year had slightly more fish in their diet than in previous years. The mean length of krill in fur seal diet decreased this year over last year, reflecting the same results as found in net tows from our oceanographic survey. As our monitoring program at Cape Shirreff continues, we are collecting valuable data on post weaning survival and return of fur seal neonates. Poor juvenile survival has been implicated as a primary source of declines in other otariids (York, 1994). Data on juvenile survival from Cape Shirreff will lead to a better understanding of the oceanographic conditions that lead to successful recruitment and sustainability of otariid populations.

5.4 Acknowledgements: The National Science Foundation provided support and transportation to the Cape Shirreff field site for the opening camp crew. We thank the captain, crew and science staff of the November cruise of the R/V *Nathaniel B. Palmer*. We are grateful to our Chilean colleagues: Jorge Acevedo, Romeo Vargas, Juan Pablo Torres Florez and Verónica Vallejos Marchant for their assistance in the field, good humor and for sharing their considerable knowledge and experience of Cape Shirreff. Some of the tag re-sight data used in this report were provided by our Chilean colleagues. Thanks to Iris Saxer, Dana Scheffler and Wayne Trivelpiece for their help with pinniped studies. We are, likewise, grateful to the AMLR personnel and the Russian crew of the R/V *Yuzhmorgeologiya* for their invaluable support and assistance to the land-based AMLR personnel. All pinniped research at Cape Shirreff was conducted under Marine Mammal Protection Act Permit No. 774-1649 granted by the Office of Protected Resources, National Marine Fisheries Service.

5.5 References:

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Reid, K., and Measures, J. 1998. Determining the sex of Antarctic krill *Euphausia superba* using carapace measurements. *Polar Biology* 19(2): 145-147.

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Table 5.1. Summary statistics for the first six trips and visits (non-perinatal) for female Antarctic fur seals rearing pups at Cape Shirreff, Livingston Island, 1997/98 – 2001/02.

Year	Female N	N	Range	Median	Mean	St.Dev.	Skew[1]	SE Skew	S[1]	(+/-)
Trip durations:										
1997/98	30	180	0.50 -9.08	4.07	4.19	1.352	0.083	0.181	0.459	-
1998/99	31	186	0.48 -11.59	4.23	4.65	1.823	0.850	0.178	4.775	+
1999/00	23	138	0.60 -8.25	3.25	3.47	0.997	1.245	0.206	6.044	+
2000/01	28	168	0.75 -5.66	2.69	2.71	0.828	0.874	0.187	4.674	+
2001/02	28	166	0.50 -7.85	2.87	3.18	1.207	0.740	0.188	3.936	+
Visit durations:										
1997/98	30	179	0.46 -2.68	1.25	1.35	0.462	0.609	0.182	3.346	+
1998/99	31	186	0.21 -3.49	1.27	1.33	0.535	0.947	0.178	5.320	+
1999/00	23	138	0.10 -4.25	1.51	1.72	0.635	1.088	0.206	5.282	+
2000/01	28	168	0.44 -3.15	1.52	1.68	0.525	0.485	0.187	2.594	+
2001/02	28	166	0.19 -4.84	1.43	1.55	0.621	1.328	0.188	7.094	+

[1]Skewness: A measure of asymmetry of the distribution of the data. A significant positive value indicates a long right tail. Significance (S) is indicated when the absolute value of Skewness/Standard Error of Skewness (SE) is greater than two.

Table 5.2. Results of a contingency table on the proportions of major prey types (krill, fish, and cephalopods) in Antarctic fur seal scats and enemas collected at Cape Shirreff, Livingston Island in four years of collections, 1998/99 through 2001/02 (X^2=30.8, d.f.=6, P<0.0005). Reject H_o: The proportions of krill, fish, and squid in the diet are homogeneous in the four years of study.

	1998/99		**1999/00**		**2000/01**		**2001/02**	
Prey	**Observed**	**Expected**	**Observed**	**Expected**	**Observed**	**Expected**	**Observed**	**Expected**
Krill	84	74.2	94	105.0	104	84.0	111	129.0
Fish	32	45.1	71	64.2	39	51.1	97	78.6
Squid	12	8.7	17	12.3	2	9.8	15	15.1

Table 5.3. Krill length (mm) in fur seal diet from 1999/00 - 2001/02. Data are derived from measuring length and width of krill carapaces found in fur seal scats and applying a discriminant function to first determine sex before applying independent regression equations to calculate total length.

	1999/00:			**2000/01:**			**2001/02:**		
Krill Length (mm)	**All Krill**	**Female**	**Male**	**All Krill**	**Females**	**Males**	**All Krill**	**Females**	**Males**
N:	2528	1623	905	2941	1578	1363	2826	1983	843
Median:	50.8	52.9	48.3	52.9	52.9	52.8	55.0	55.0	52.8
Mean:	50.6	52.0	47.9	53.1	53.6	52.5	53.8	54.3	52.4
St. Dev.:	4.46	3.31	5.00	3.82	3.57	4.02	4.44	3.59	5.77
Maximum:	59.7	59.2	59.7	39.1	40.4	39.1	64.3	63.4	64.3
Minimum:	13.9	40.4	13.9	64.3	63.4	64.3	36.8	38.3	36.8
Sex Ratio (M:F):	1:1.8			1:1.2			1:2.4		

Table 5.4. Tag returns and pregnancy rates for adult female fur seals at Cape Shirreff, Livingston Island, 1998/99 – 2001/02.

Year	Known Tagged Population[1]	Returned	Pregnant	% Return	% Pregnant	Tags Placed	Primaparous females tagged as pups
1997/98						37[2]	0
1998/99	37	31	28	83.8	90.3	52	0
1999/00	83	78	72	94.0	92.3	100	0
2000/01	173	156	136	90.4	87.2	35	0
2001/02	195[3]	191	174	97.9	91.1	42	2

[1]Females tagged and present on Cape Shirreff beaches the previous year.
[2]Includes one female present prior to the initiation of current tag studies.
[3]Includes one female tagged as an adult with a pup in 1998/99, which was present in 1999/00 but was never observed in 2000/01.

Table 5.5. A comparison of first year tag returns for four cohorts: 1997/98 – 2000/01. Values in parentheses are percent total tagged.

Cohort	Total Tags Placed	Tag Returns in Year 1 (%) Total	Males	Females
1997/98	500	22 (4.4)	10 (2.0)	12 (2.4)
1998/99	500	6 (1.2)	5 (2.0)	1 (0.4)
1999/00	500	26 (5.2)	15 (3.0)	11 (2.2)
2000/01	499	7 (1.4)	4 (1.7)	3 (1.1)

Table 5.6. Tag returns and minimum percent survival for three cohorts, 1997/98 – 1999/00 using only the first two years of re-sight data for each cohort. Assuming cohort return rates correlate with survival and are similar for each cohort, our data show survival to age-1 varies considerably.

	1997/98			1998/99			1999/00		
	Females	**Males**	**TOTAL**	**Females**	**Males**	**TOTAL**	**Females**	**Males**	**TOTAL**
Sightings:									
Sighted in Year 1:	12	10	22	1	5	6	11	15	26
Additional Tags Sighted in Year 2:	20	10	32	6	7	13	53	40	93
Minimum survival in year 1:	32	20	54[1]	7	12	19	64	55	119
Tag loss:									
Unknown tag status:	2	1	3	0	2	2	1	3	4
Both tags present:	14	13	29	6	6	12	48	42	90
Missing 1 tag:	16	6	22	3	2	5	15	10	25
Probability of missing one tag:	0.53	0.32	0.43	0.33	0.25	0.29	0.24	0.19	0.22
Probability of missing both tags[2]:	0.28	0.10	0.19	0.11	0.06	0.09	0.06	0.04	0.05
Survival estimates:									
Minimum % Survival 1st year:	12.80	8.00	10.8	2.8	4.8	3.8	27.6	20.6	23.8
Adj. Min. % Survival for year 1[3]:	16.44	8.80	**12.8**	3.1	5.1	**4.1**	29.2	21.4	**25.0**

[1]Includes two sightings of seals of unknown sex.
[2]Assumes tag loss is independent for right and left tags.
[3]Minimum percent survival adjusted for double tag loss.

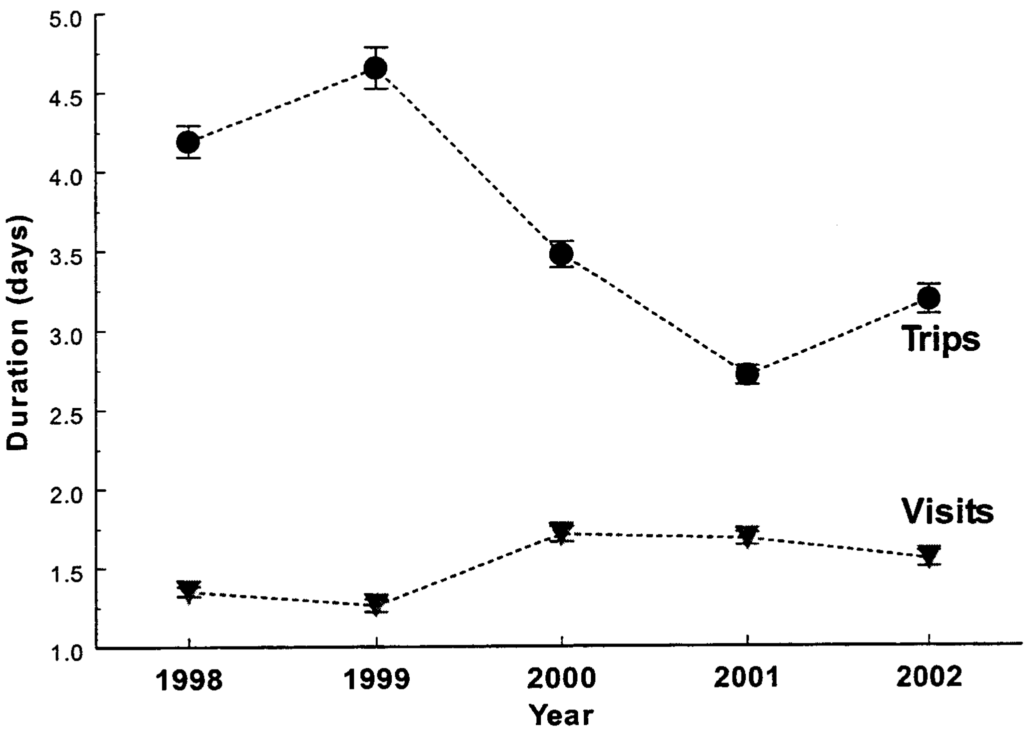

Figure 5.1. Antarctic fur seal trip and visit durations for females rearing pups at Cape Shirreff, Livingston Island. Data plotted are for the first six trips to sea and the first six non-perinatal visits following parturition for four years (**1997/98:** $N_{Females} = 30$, $N_{Trips} = 180$; **1998/99:** $N_{Females} = 31$, $N_{Trips} = 186$; **1999/00:** $N_{Females} = 23$, $N_{Trips} = 138$; **2000/01:** $N_{Females} = 28$, $N_{Trips} = 168$; **2001/02:** $N_{Females} = 28$, $N_{Trips} = 166$). Sample sizes for visits are the same as trips.

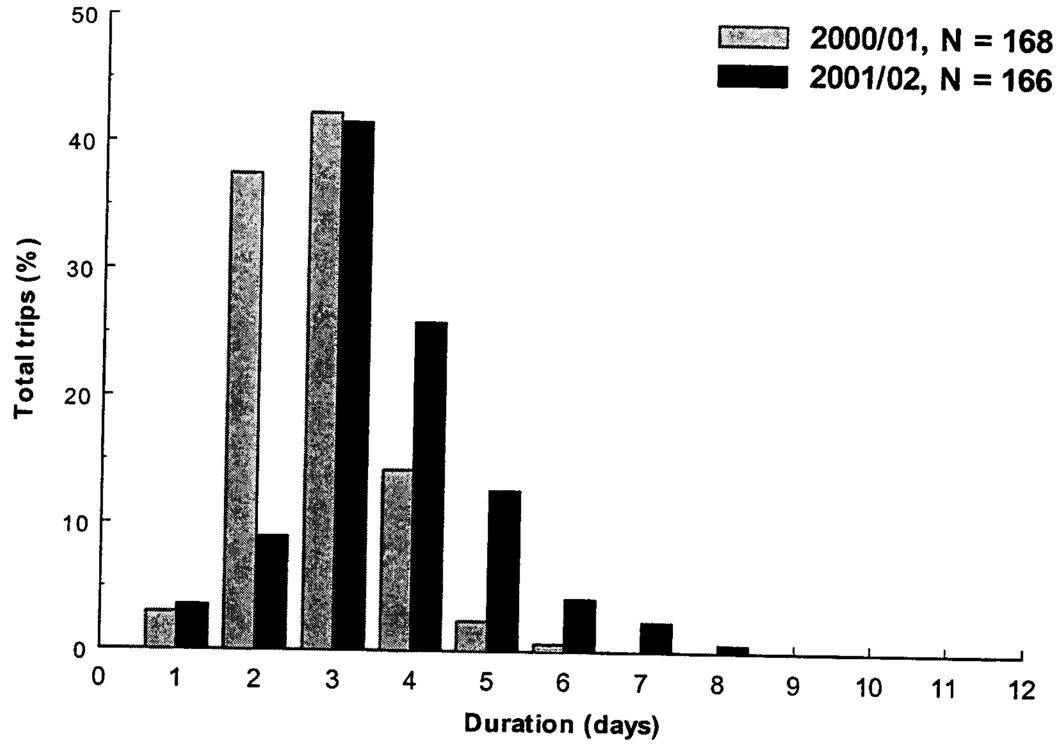

Figure 5.2. The distribution of Antarctic fur seal trip durations at Cape Shirreff, Livingston Island for the last two years (2000/01-2001/02).

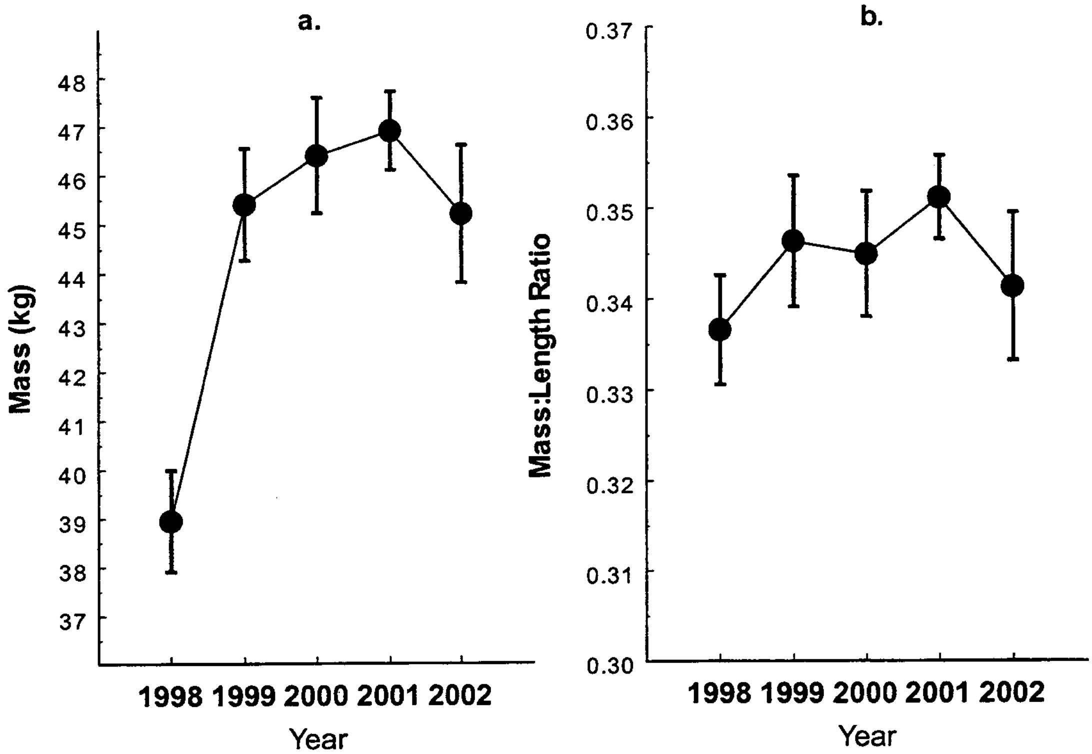

Figure 5.3. The mean mass (a.) and mass:length ratio (b.) for CCAMLR Attendance Study females for 1997/98 – 2001/02 (1997/98: **N=31,** 1998/99: **N=32,** 1999/00: **N=23,** 2000/01: **N=28,** 2001/02: **N=28).**

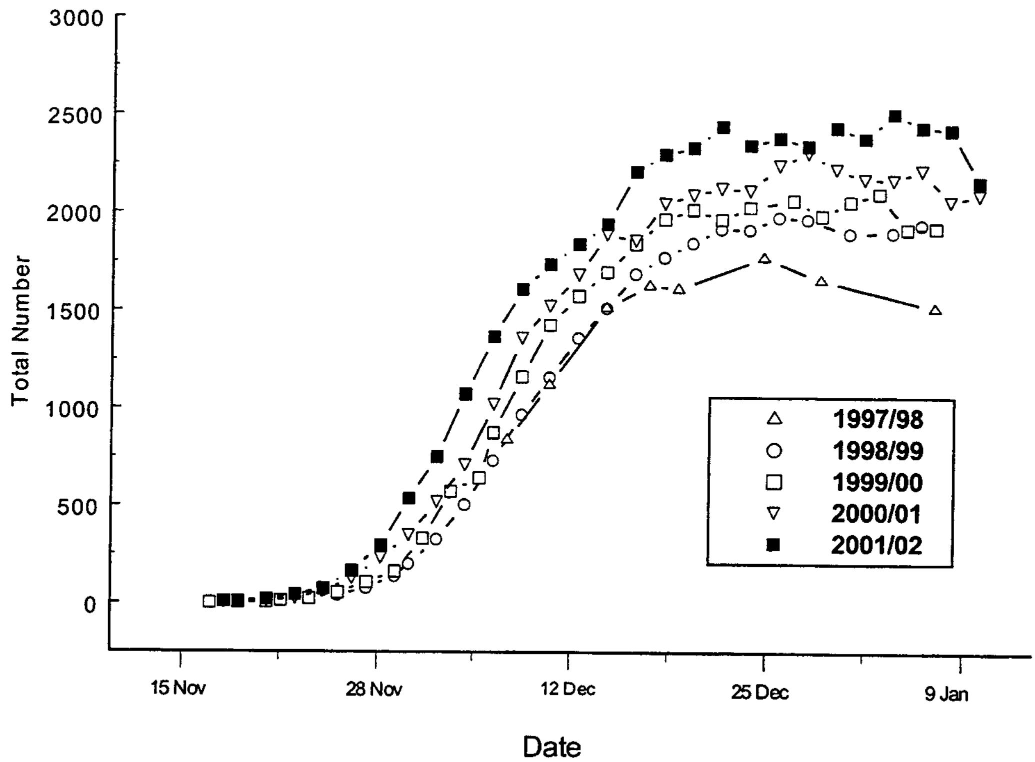

Figure 5.4. Antarctic fur seal pup production at U.S.-AMLR study beaches, Cape Shirreff, Livingston Island, 1997/98-2000/02.

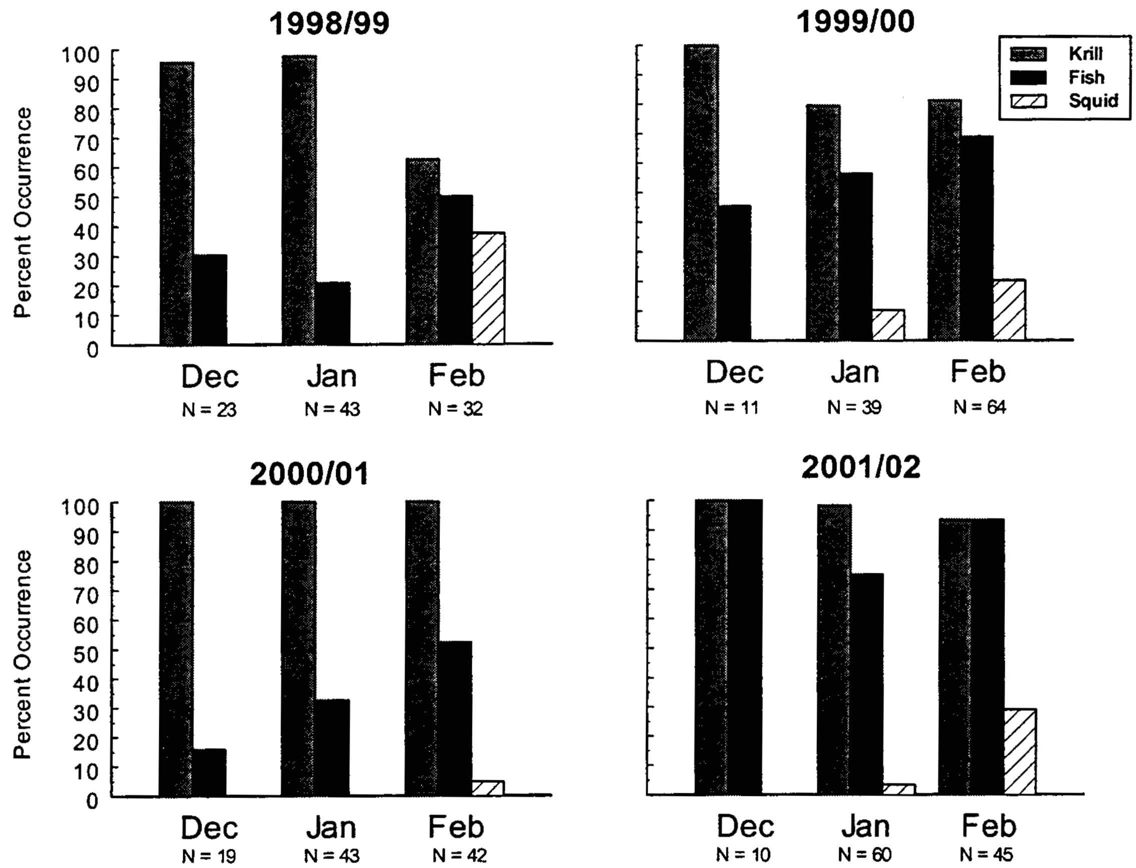

Figure 5.5. The percent occurrence of primary prey types (krill, fish, and squid) from December through February for Antarctic fur seal scats and enemas collected from female suckling areas at Cape Shirreff, Livingston Island for 1998/99 through 2001/02.

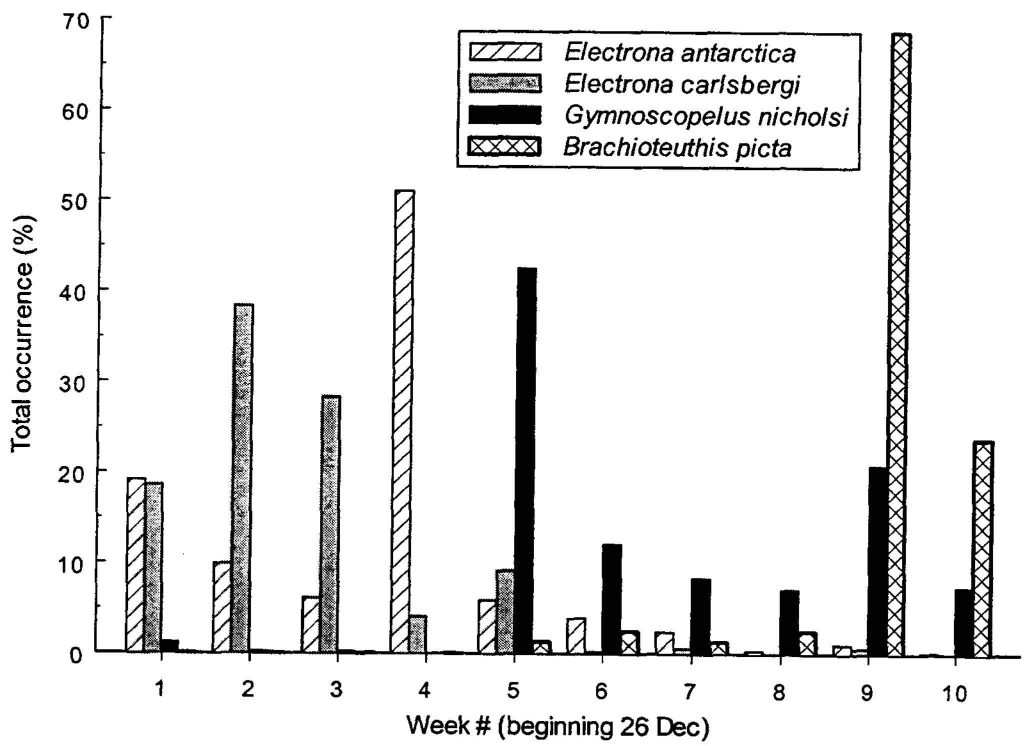

Figure 5.6. The weekly percent occurrence of the primary non-krill species found in fur seal diets at Cape Shirreff, Livingston Island in 2001/02. The four species are *Electrona antarctica*, *Electrona carlsbergi*, *Gymnoscopelus nicholsi*, and *Brachioteuthis picta*. The first three species are myctophid fish (lantern fish) and the fourth species is a cephalopod (squid).

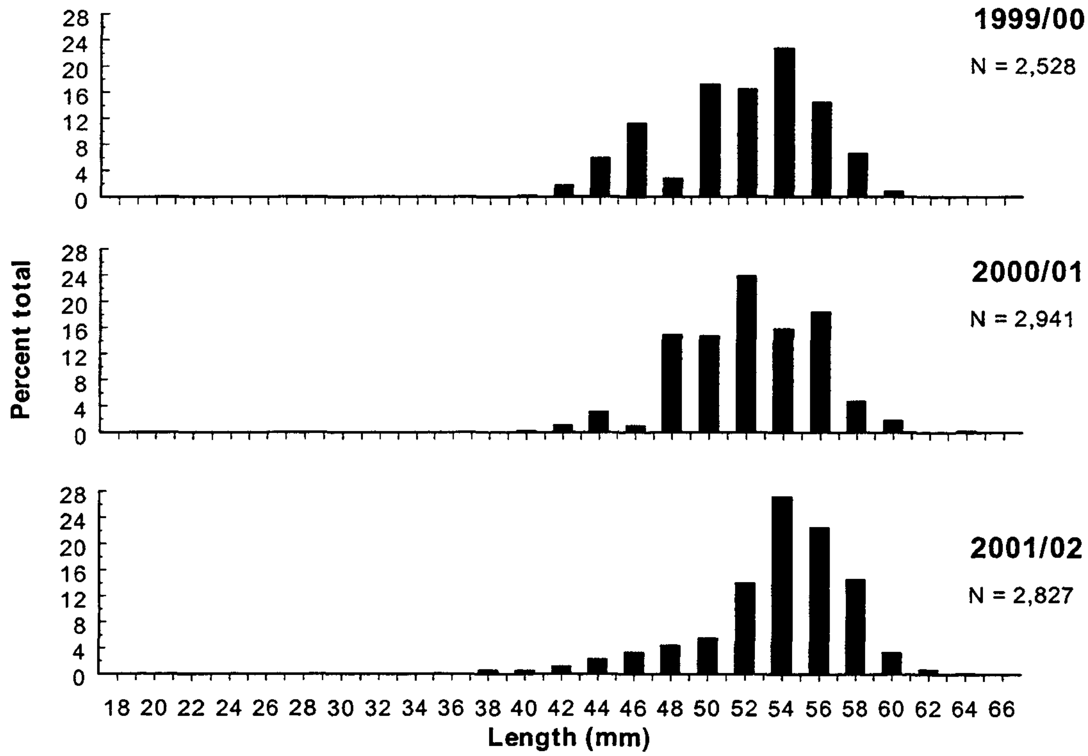

Figure 5.7. The size distribution of krill in Antarctic fur seal diet at Cape Shirreff, Livingston Island in 1999/00 and 2001/02.

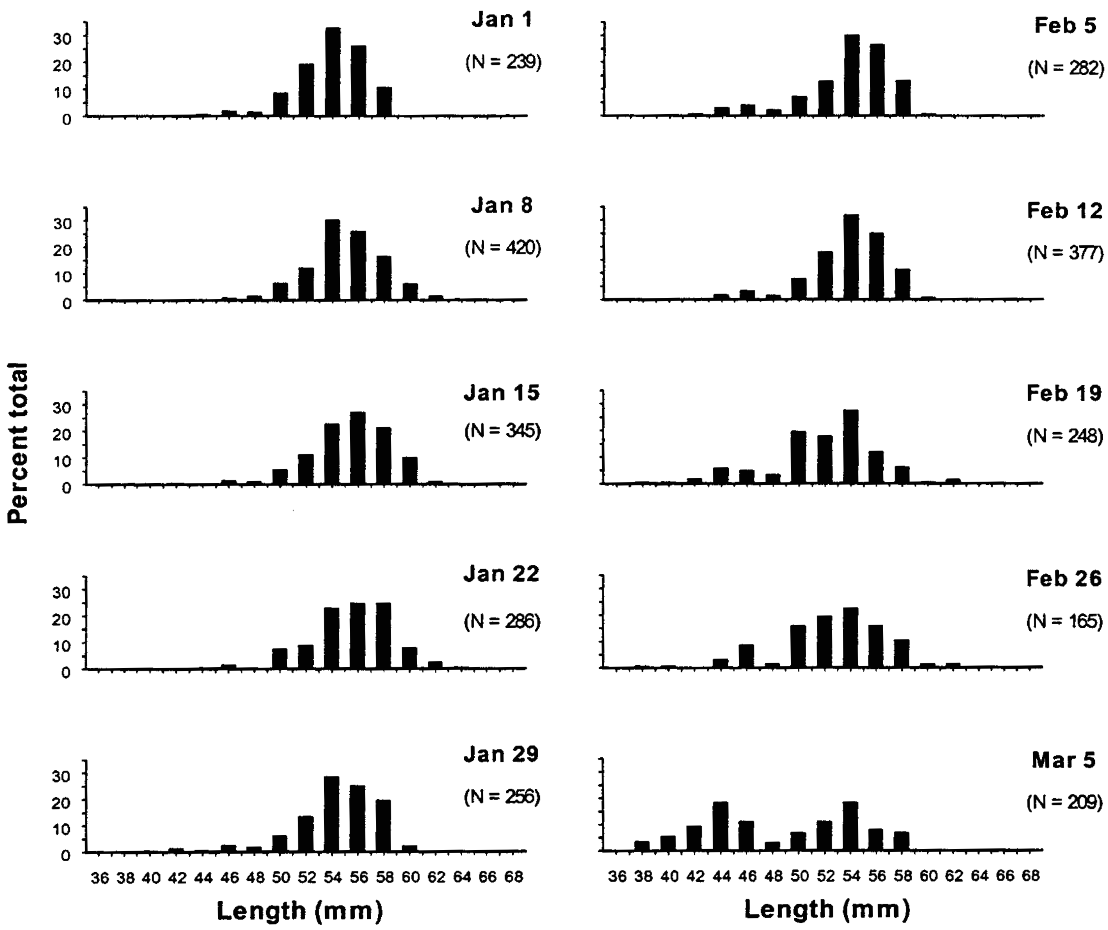

Figure 5.8. Weekly size distribution of krill (*Euphausia superba*) in Antarctic fur seal diet at Cape Shirreff, Livingston Island in 2001/02. Each plot represents one week of krill carapace measurements. The date on each plot is the last day of the week (e.g. Jan 1: the week 26 Dec 2001-1 Jan 2002). The number of krill carapaces measured for each week is given in parentheses. Large area oceanographic surveys (west area grid) by the R/V *Yuzhmorgeologiya* were conducted 16-19 January and 24-27 February (Weeks 4 and 8 in this plot; 22 Jan and 26 Feb).

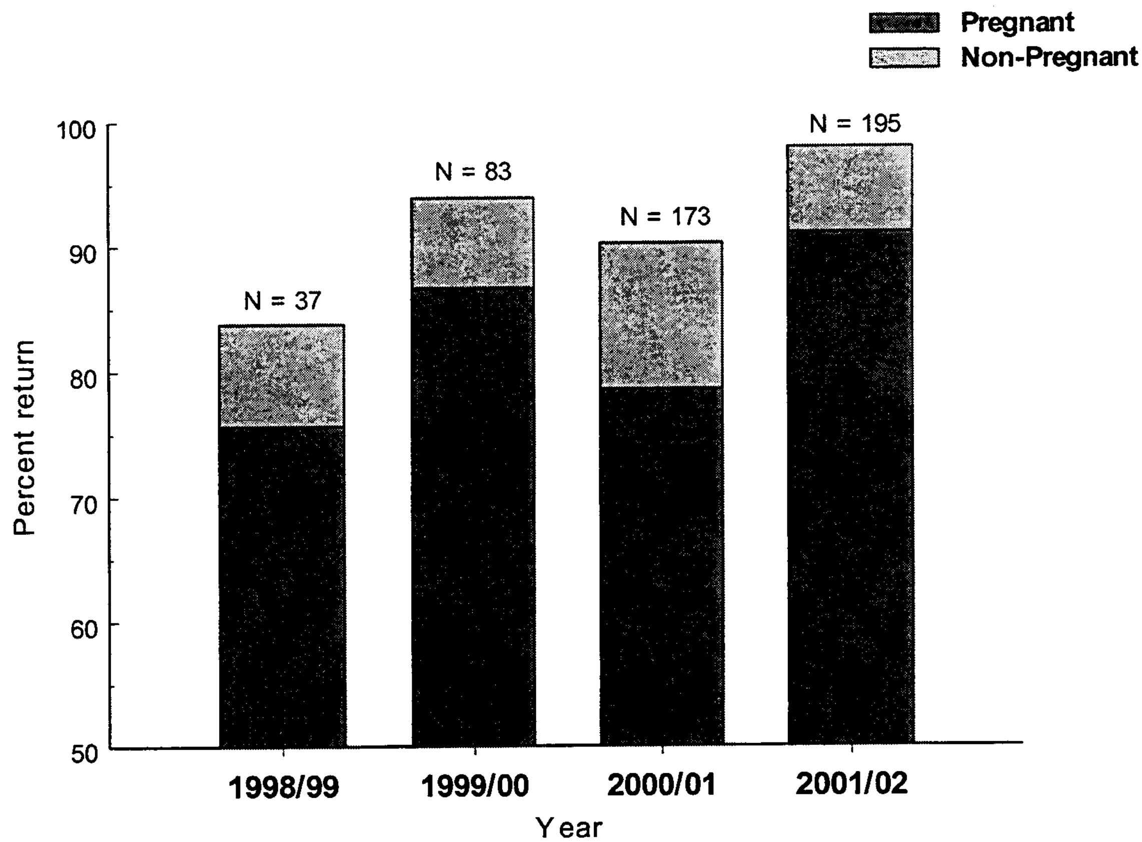

Figure 5.9. Adult female Antarctic fur seal tag returns for four years (1998/99-2001/02) at Cape Shirreff, Livingston Island.

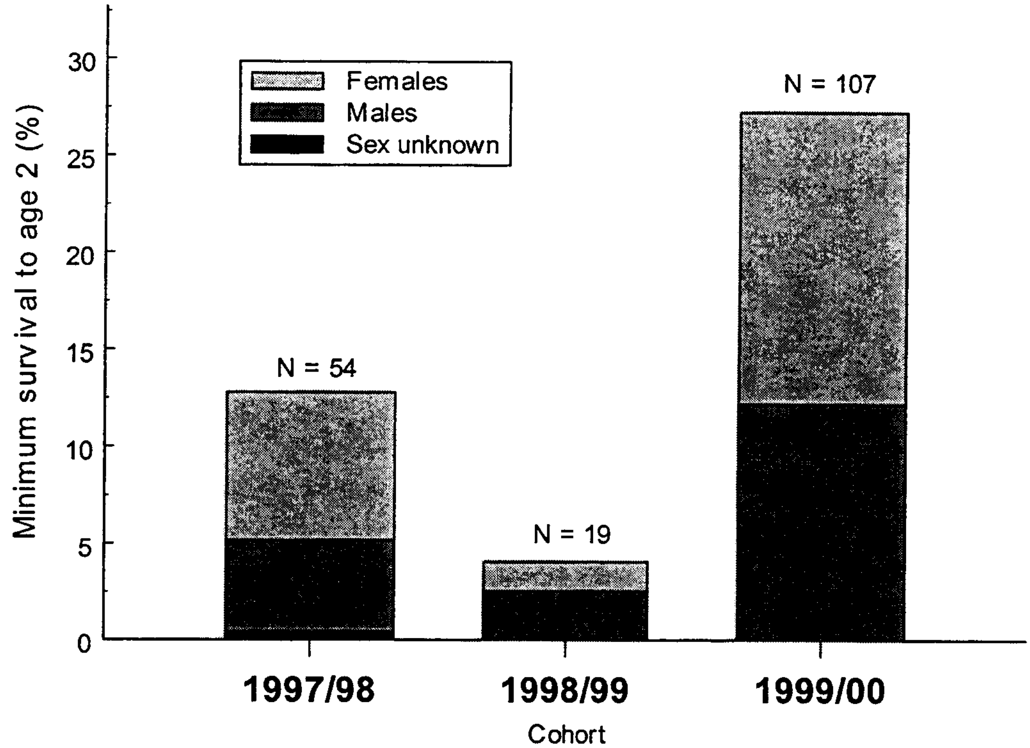

Figure 5.10. Minimum survival to age-1 based on tag returns for the first two years for three cohorts (1997/98, 1998/99, and 1999/00) of fur seals tagged as pups at Cape Shirreff, Livingston Island. Not all pups that survive their first year return as yearlings or two year olds, thus our estimates represent a minimum survival. Tag re-sight effort is assumed to be the same for all cohorts.

6. Seabird research on Cape Shirreff, Livingston Island, Antarctica, 2001-2001; submitted by Iris M. Saxer, Dana A. Scheffler, and Wayne Z. Trivelpiece.

6.1 Objectives: The austral summer of 2001-2002 marked the fifth season of land-based predator research conducted by the United States Antarctic Marine Living Resources (AMLR) program at Cape Shirreff, Livingston Island, Antarctica (62°28'S, 60°46'W). Through long-term monitoring of krill predator populations, our research on Cape Shirreff contributes to U.S. participation in the international CCAMLR (Convention for the Antarctic Marine Living Resources). Our objectives for the 2001-2002 seabird season were:

1. To estimate chinstrap and gentoo penguin breeding population size (CCAMLR Ecosystem Monitoring Program (CEMP) Standard Method 3a);

2. To band 500 chinstrap and 200 gentoo penguin chicks for demography studies (CEMP Standard Method 4a);

3. To determine chinstrap and gentoo penguin foraging trip durations during the chick rearing stage of the reproductive cycle (CEMP Standard Method 5a);

4. To determine chinstrap and gentoo penguin breeding success (CEMP Standard Methods 6a, b & c);

5. To determine chinstrap and gentoo penguin chick weights at fledging (CEMP Standard Method 7c);

6. To determine chinstrap and gentoo penguin diet composition, meal size, and krill length frequency distributions via stomach lavage (CEMP Standard Methods 8a,b & c);

7. To determine chinstrap and gentoo breeding chronologies (CEMP Standard Method 9).

6.2 Accomplishments: We opened the Cape Shirreff field camp on 14 November 2001 with the assistance of the National Science Foundation (NSF) vessel *R/V Nathaniel B. Palmer,* which provided logistical support and transit from Punta Arenas, Chile to Cape Shirreff. On 15 January 2002, two additional scientists arrived aboard the U.S. AMLR-chartered vessel *R/V Yuzhmorgeologiya* and one more scientist joined the crew on 5 February 2002. Research continued until camp closure on 10 March 2002. Return passage from Cape Shirreff to Punta Arenas, Chile was provided by the *R/V Yuzhmorgeologiya.*

6.3 Results and Tentative Conclusions:

6.3.1 Breeding Biology Studies: The penguin rookery at Cape Shirreff is comprised of 28 active breeding colonies: 13 chinstrap penguin (*Pygoscelis antarctica*) colonies, seven gentoo penguin (*P. papua*) colonies, and eight colonies with both penguin species. To determine penguin breeding population size, we counted all breeding pairs in all breeding colonies approximately one week after the peak clutch initiation date for both species. Gentoo penguins were censused on 23 and 24 November and chinstrap penguins on 29 November and 1 December 2001. A total of 907 gentoo and 6,606 chinstrap penguin pairs bred at Cape Shirreff in 2001/02. Penguin populations have been censused at Cape Shirreff annually since 1997/98. The 2001/02 population counts represents the lowest chinstrap penguin count on record. The gentoo penguin population was down considerably from last year, but was within the five-year averages.

We determined reproductive success by banding and following a sample of 100 chinstrap and 50 gentoo penguin pairs from the start of egg laying until the chicks entered crèches. The mean nest initiation date for chinstraps was 20 November and ranged from 16-30 November. Gentoo penguins on average nested earlier, with a mean clutch initiation date of 7 November and a range from 25 October to 22 November. Gentoo penguin pairs nesting in colonies on the west side of the Cape Shirreff peninsula laid eggs two weeks earlier than east side pairs, possibly due to earlier availability of snow-free nest sites. Mean clutch initiation date for the west colonies was 1 November and east colonies was 15 November. All gentoo penguin census and weighing dates were adjusted to account for this disparity. Mean chinstrap penguin clutch initiation dates coincided exactly with dates from the past two seasons; however, gentoo penguins laid eggs a mean ten days early than previous seasons. Chinstrap penguins hatched 0.97 chicks per pair and fledged 0.73 chicks per pair. Seventy-five percent of all chicks that hatched survived to fledging. Gentoo penguins had significantly higher reproductive success during the 2001/02 season, hatching 1.66 chicks per pair and fledging 1.32 chicks per pair. Eighty percent of all chicks that hatched survived to fledging. Chinstrap penguin reproductive success in 2001/02 was the lowest on record for Cape Shirreff, while gentoo penguin reproductive success was within the five-year averages. This season we had a significant increase in the number of known-age chinstrap and gentoo penguins breeding. These birds were banded as chicks at Cape Shirreff and have returned to their natal colonies to breed. Thirty known-age chinstraps and eleven known-age gentoo penguins attempted to breed, although only ten chinstrap and two gentoo penguin pairs successfully fledged chicks.

We conducted the annual chinstrap penguin chick census on 8-9 February. Gentoo penguin chicks were censused on 20 January and 3 February to account for the two-week difference between the west and east side colonies' clutch initiation dates. A total of 7,432 chinstrap and 1,061 gentoo penguin chicks survived to crèche age this breeding season. This season represented a 23.7% decline for chinstrap penguins and an 18.3% decline for gentoo penguin chicks, compared to the 2000/01 counts.

As part of our ongoing demographic study, we banded a sample of 500 chinstrap penguin chicks on 10 February, and 200 gentoo penguin chicks on 25 January and 7 February. We will continue to collect future demographic data on these and other known-age birds as they return to the rookery to establish territories, select mates and breed.

From 15-23 February, we captured and weighed a sample of 256 chinstrap penguin chicks as they congregated on rookery beaches in preparation for fledging to sea. The mean chinstrap penguin chick fledging weight for the season was 3,202g, which is slightly higher than last year but comparable to other years. We also collected 85-day weights for gentoo penguin chicks. Gentoo penguins do not fledge in the traditional sense. They continue to receive supplemental feedings by their parents during their early at-sea foraging trips. We therefore obtain comparable weights 85 days after the peak clutch initiation date. Chicks are approximately seven weeks old at this time, the age at which the other two species of *Pygoscelis* penguins fledge. We weighed

125 gentoo penguin chicks on 25 January and 75 chicks on 7 February. The mean weight for this sample was 4494g, down slightly from last year's gentoo penguin chick weights.

6.3.2 Foraging Ecology Studies: We collected 40 chinstrap and 20 gentoo penguin diet samples between 6 January and 18 February 2002 to determine meal size and prey composition of food delivered to chicks by foraging adults. All sampled adults were verified breeders as individuals were captured at the nest site just before feeding their chicks. Stomach contents were removed by lavaging, sorted into prey types and weighed to the nearest 0.1 gram. The dominant prey species in the diet samples was krill (*Euphausia superba*), which we found in 100% of samples from both chinstrap and gentoo penguins. Chinstrap penguin diets were composed almost entirely of krill with only 15% of samples containing otoliths or trace amounts of fish. Gentoo penguins consumed more fish with 70% of the diet samples containing some portion of fish in addition to krill. We used otoliths collected from samples to identify fish species in the diet. Analysis of length-frequency distribution of krill in the penguins' diets revealed a wide range of krill size classes from 18mm to 63mm with approximately 10-26% of krill in each of five CCAMLR size classes: 31-35mm, 36-40mm, 41-45mm, 46-50mm, and 51-56mm. This is a shift from the past four seasons where penguin diets have shown a distinctive peak of 40-50% of all krill in one CCAMLR size class (Figure 6.1). This peak is believed to represent the strong 1994/95 krill cohort that has dominated the diets of penguins at Cape Shirreff in the four previous years and may be dying off now.

To determine penguin foraging trip durations throughout the chick-rearing phase, we attached radio transmitters to 19 adult chinstrap penguins and ten gentoo penguins with week-old chicks. We tracked their foraging trips from the first week in January until the chicks fledged in late February. All data were received by a remote antenna and stored by a field computer located at our bird blind in the penguin rookery. Mean foraging trips were 12.2 hours during the chick-rearing period this season, a significant increase over the 8-9 hour trip lengths in the 2000/01 season. Results of our satellite tagged birds revealed that the birds were foraging farther offshore than in the previous season, a pattern likely to account for the longer trip lengths we found in 2001/02 (see paragraph below).

To gather additional at-sea foraging data, we outfitted ten chinstrap penguins with ARGOS satellite-linked transmitters (PTTs) during the early chick-rearing phase and four gentoo penguins in the late chick-rearing phase. On 15-16 January, we deployed ten PTTs on adult chinstrap penguins to determine adult foraging locations while chicks were about three weeks old, just prior to crèche. The timing of this deployment coincided with the annual AMLR marine prey survey conducted in adjacent ocean waters. The PTTs remained on the birds for approximately 10 days before removal. We plotted at-sea foraging positions of chinstrap penguins using Surfer software and found that birds were traveling up to 30km offshore to feed at the shelf break in January 2002. This represents a very different foraging pattern from data gathered during the 2000/01 January period, when all penguin foraging activity was confined to the shelf area within 10km of the colony. On 16 February, we redeployed four PTTs on gentoo penguins with 7-8 week-old chicks to track later season foraging locations. This timeframe coincided with the AMLR nearshore hydroacoustic survey of Cape Shirreff. Gentoo penguin foraging patterns were well inshore of the Chinstrap foraging areas used a month earlier; and all birds foraged within 15km of the colony. Detailed analyses of both species foraging patterns during the last three seasons are under way. In addition, one PTT was not retrieved from the final deployment and remained on a gentoo penguin throughout its 2-3 weeklong pre-molt foraging trip. This is the first time data have been colleted on gentoo penguin foraging behaviors during the pre-molt period.

To study penguin diving behavior during the chick-rearing phase, we placed eight time-depth recorders (TDRs) on adult chinstrap and gentoo penguins with chicks. The timing of both deployments (10 and 21 January) coincided with the AMLR marine prey survey. The TDRs gathered data on variables such as the dive depth, duration, time, and sea temperature. We are currently analyzing data on penguin diving profiles collected by the time-depth recorders.

In addition to our penguin research, we studied the breeding biology of the brown skua (*Catharacta antarctica lonnbergi*). Brown skuas are key predators on the Cape Shirreff penguin population. Penguin eggs and chicks provide a major food source for brown skuas during the breeding season. Throughout the season, we followed the reproductive success of all brown skua breeding territories (n=19) on Cape Shirreff and one territory off the cape. Brown skua reproductive success was lower this year that in previous years with 1.25 chicks hatched per pair and .95 chicks fledged per pair. We have banded all breeding brown skuas in previous seasons. In 2001/02, we banded one new adult female and all chicks born this year and collected measurements of culmen length and depth, tarsus length, and weight. Brown skua chicks begin returning to their natal grounds as three-year-olds. We began banding chicks in the 1996/97 austral summer. The number of returning known-age skuas at Cape Shirreff is slowly increasing each year with six known-age birds observed in 1999/00 and twelve observed in 2000/01. During the 2001/02 season we resighted a total of 14 known-age skuas, although only four of these were first time observations. We also followed reproductive performance of kelp gulls (*Larus dominicanus*) opportunistically throughout the season.

6.4 Future Research: Our future research plans include the continuation of the annual CCAMLR predator monitoring protocols and at-sea foraging behavior studies with TDRs and PTTs. These methods, in association with the Antarctic fur seal research at Cape Shirreff, and the annual AMLR marine prey survey, will allow us to further investigate and gain insight on the seasonal and inter-annual variability of the krill and predator populations in this region.

6.5 Acknowledgments: We would like to thank Michael Goebel, John Lyons, Rennie Holt, Brian Parker, and the Chilean research team (Veronica Vallejos, Jorge Acevedo, Juan Pablo Torres Florez, and Romeo Vargas) for providing assistance, friendship and laughter throughout the field season. We thank the crew of the NSF R/V *Nathaniel B. Palmer* for providing a safe voyage to Cape Shirreff in November and for valuable assistance offloading our 5-month supply of food and scientific gear. We appreciate the hard work and diligence of the crew and AMLR scientists aboard the R/V *Yuzhmorgeologiya* in re-supplying the Cape Shirreff field camp and for a smooth migration from Antarctica to Chile at the end of the season. Special thanks to the Chilean Navy and INACH (Instituto Antartico Chileno) who graciously agreed to transport one of the authors back to Chile in February. Thanks to Sue Trivelpiece for gathering key satellite foraging data and to Stephanie Sexton for keeping us in touch with the world beyond the Cape. Special thanks and gratitude to our partners, family and friends for their emails, letters, and support.

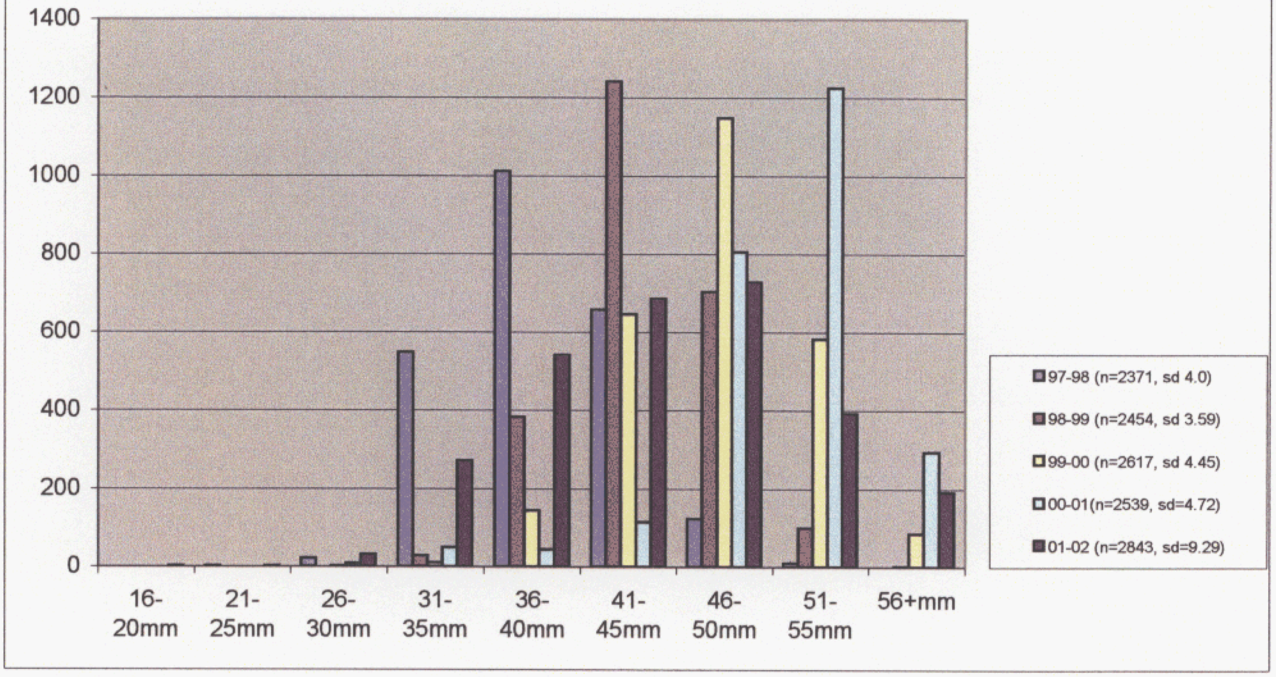

Figure 6.1. Krill length-frequency distribution from chinstrap and gentoo penguin diet samples at Cape Shirreff, Livingston Island, Antarctica 1997-2002.

7. Antarctic fur seal pup production in the South Shetland Islands; by Michael E. Goebel, Verónica I. Vallejos, Wayne Z. Trivelpiece, Rennie S. Holt and Jorge Acevedo.

7.1 Objectives: This section reports the results of a census of fur seal pups throughout the South Shetlands from 30 January – 5 February 2002. All sites reported to have pups in previous censuses (1986/87, 1991/92, and 1995/96) were visited. Two ice-free capes on the southern coast of King George Island (KGI) were also visited as well as Black Point on the north coast of Livingston Island. The two south coast sites of King George Island were chosen based upon an unpublished, anecdotal report that a number of fur seal pups were observed at Turret Point (KGI) during the 1999/00 austral summer. The two sites have suitable breeding habitat and were known to have substantial numbers of sub-adult and adult males hauling out. Currently all known fur seal colonies are on the northern coasts of the South Shetlands. Documenting colonization by breeding females on a south coast site would represent a major event in the history of recovery of this exploited population.

In addition, we compare the results of this survey with those from previous surveys conducted by the U.S. Antarctic Marine Living Resources Program in 1986/87, 1991/92, 1993/94, and 1995/96 and report on the rates of change in colony size between censuses.

7.2 Methods: The South Shetland Islands are situated south of the Drake Passage, 450 nautical miles southeast of Cape Horn off the northern flank of the Antarctic Peninsula, from which they are separated by the Bransfield Strait. They range from approximately 54.0°W to 63.0°W longitude and from 61.0°S to 63.5°S latitude (Figure 7.1).

Only pups were counted for this survey. Antarctic fur seal pups are born from late November to early January. Females arrive on shore approximately 1-2 days before giving birth. After tending to their pups for about a week they depart to sea to begin a series of foraging trips. Pups do not begin entering the water until a month old and then only in inter-tidal areas. They do not spend significant amounts of time in the water until they molt in mid-late February and do not depart natal rookeries until they are weaned in late-March and April. Juveniles and adults are continually arriving and departing and their presence onshore is influenced by numerous factors that cannot be controlled. Thus, fur seal pups represent the only portion of the population that can be reliably counted in its entirety. Pup production is, therefore, the best index of population size and trends in population numbers over time.

All previous censuses have reported a single count of pups for each site primarily because of the ease of counting relatively lower numbers of pups provided higher confidence in accuracy of the count. As the population has grown to thousands of individuals, variability in counts is now more likely. In order to provide confidence limits on pup production we had 3-4 individual counters at each site.

One day prior to the start of the census (29 January), the three primary counters censused an area (sub-colony) of Cape Shirreff approximately equal to the size of most South Shetland colonies. This count was done separate from the entire count of Cape Shirreff and was conducted to estimate intra-observer variability in counting. Each observer counted the area for live and dead pups three times. The colony was divided into three sections and each observer started their counts in a different section. Pup mortality at the same area was monitored throughout the breeding season (18 November -10 January) by counting newly dead pups every day. Thus, a comparison of pup mortality measured by counting dead pups during the census with actual mortality throughout the breeding season was available.

In all colonies counting of both live and dead pups was by direct observation using hand held counters. At all sites, three to four observers counted pups. At one site, north San Telmo Island, the largest continuous breeding colony in the South Shetlands, instead of counting both live and dead pups, three counters counted live pups and one counter was solely dedicated to counting dead pups. Fur seal breeding areas in the South Shetlands are free of tussock grass or any vegetation, which can obscure pups. At each site the support vessel (R/V *Yuzhmorgeologiya*) would anchor or hove to offshore and a zodiac would be launched with a team of five to six people. Two people remained in the zodiac offshore of a colony while the other three to four were put ashore to count. While the counting crew was onshore, the zodiac surveyed beaches near colonies for any additional breeding groups. Landings were made at all but two sites, Fildes Peninsula and Cape Melville, King George Island. At both these sites no colonies had ever been reported but numerous adult and sub-adult males haul out; so surveys of extensive areas of the coastline were conducted by traveling approximately 15-30 meters from shore.

The census was conducted from 30 January-5 February 2002, well after the last pups are born (the last observed newborn pup at Cape Shirreff in 2001/02 was 10 January; U.S. AMLR unpublished data). Inclement weather can influence visibility and fur seal behavior, which in turn may influence variability in counts; thus, at each census location, weather, tide, and visibility were recorded.

7.3 Results: Measures of intra-observance variance from a selected area of Cape Shirreff are presented in Table 7.1. All counts were within 10% of individual means (max: 8.78%). Individual means were all within 3% of the grand mean.

Weather, visibility, and census conditions were generally excellent for the survey. Table 7.2 lists each site visited, latitude, longitude, date, census time, and weather conditions. Visibility at Cape Lindsey, Stinker Point, and Stigant Point was only fair due to fog. However, these conditions only affected finding the site and landing; once on shore, conditions did not affect counting of pups.

The distribution throughout the South Shetlands of colonies censused is shown in Figure 7.1. Total Antarctic fur seal pup production for the South Shetlands was 10,057 ±142 (Table 7.3). Cape Shirreff, Livingston Island accounted for 64.2% (6,453 pups) of the total and San Telmo Islets off the northwest coast of Cape Shirreff accounted for an additional 21.1% (2,124 pups) of the total (Table 7.3, Figure 7.2). All other sites (n=12) had colonies of less than 500 pups (Table 7.3, Figure 7.2). Dead pups (138 ±5.4) accounted for 1.4% of the total.

Only one site reported to have pups by previous survey teams was not visited. The site is one of three small islands in the Seal Island group and in previous surveys it has been called Saddle Rock due to its shape when viewed from a distance at sea. Saddle Rock also has a cave where previous census teams have found pups. For the purpose of calculating total pup production, the count of pups at Saddle Rock was estimated at 63 pups (Table 7.3). The estimate is based upon an adjustment of the last count of Saddle Rock (101 pups in 1995/96) and applying the average rate of change at other sites in the Seal Islands between the 1995/96 census and the current census (Table 7.4).

Pup mortality at a selected site at Cape Shirreff (the same site censused for a calculation of intra-observer variance) recorded throughout the breeding period (~18 November-10 January) indicated a cumulative total of 52 dead pups (Figure 7.3). The mean for dead pups counted at the same site 19 days later was 12.7 (±1.74).

7.4 Discussion: A comparison of this census with previous censuses revealed a net increase of 0.9% in pup production since the last census in 1995/96 (Table 7.4). The increase was not consistent with all colonies. The greatest rates of increase (averaged annual) were at Cape Shirreff (5%) and Start Point, Livingston Island (2.7%). Cape Valentine, Elephant Island had a slight increase (0.3%), while Stigant Point, KGI showed no change. Seal Islands, Cape Lindsey, Elephant Island, Window Island, and San Telmo Island showed net decreases. The largest per capita decrease was at San Telmo Island (-3.5%) and Cape Lindsey had the largest percentage decrease (-9.4%).

The average annual rate of increase for all colonies combined from 1986/87 to 1991/92 was 13.5% (Table 7.4, Figure 7.4). From 1991/92 to 1993/94 the rate of increase remained similarly high at 13.9%. For the next two years, the averaged annual rate of increase declined to 8.5%, and for the last six years (1995/96-2001/02), the rate declined even further to 0.9%.

The fact that rates of change at individual colonies were not similar across the archipelago suggests that the differences are, at least in part, the result of local phenomena and not a regional-scale cause. The differences in the averaged annual rate of change were also large enough not to be associated with counting variance. It is particularly interesting that, at the two sites where there are "mainland" colonies and offshore island colonies, that the offshore islands (Window Island and San Telmo Island) showed decreases and the "mainland" colonies (Start Pt. and Cape Shirreff) had increases. At both these sites, the offshore island colonies are less than a kilometer away from "mainland" colonies, thus offshore resources for foraging and rearing young can effectively be considered the same for both populations (e.g. Cape Shirreff and San Telmo). This would suggest that any changes might be due to differences in the on-land habitat for breeding (e.g. colony density). For a species that lives ca. 20 years, in a rapid re-colonizing phase of growth (e.g. fur seals from 1980-1990s), the habitat available for a particular strong cohort recruited in to the adult breeding population early in a re-colonizing phase, is very different than that available in the current population. That is to say, San Telmo or Window Island may have been the best available site for breeding 15 years ago, but an immigrant from a more recent cohort may have more options as to where to breed. Large, low-density habitats more recently colonized may be a more favorable choice of where to breed.

Most colonies of fur seals in the South Shetlands are small (<500 pups) and confined to small islands off the coasts of larger islands such as Elephant and Livingston Islands. The available breeding habitat on these smaller offshore islands is extremely limited and most of these colonies are limited in their capacity to support much larger populations of fur seals. Large ice-free capes and islands such as Cape Shirreff, Byers Peninsula, Desolation Island, Rugged Island and those of the southern coasts of the South Shetlands are likely locations for future growth of fur seal populations. Of these, only Cape Shirreff and Byers Peninsula have been colonized. The population at Start Point (Byers Peninsula) is still rather small (150 pups) and though Cape Shirreff currently has a pup production in excess of 6,000 pups it still has large areas that have not been re-colonized.

Our sample measures for intra-observer variance were low and demonstrate the ease of counting pups by direct observation in the South Shetlands, where breeding and pup rearing habitat is generally open and free of tussock grass (*Poa flabellate*). Tussock grass is common at lower latitude breeding sites of this species especially South Georgia where the center of the population breeds. At lower latitude colonies, the presence of tussock grass is likely one of the greatest sources of error in estimations of pup production.

The greatest source for error in pup production estimates in the South Shetlands are likely due to the timing of the census and to accurately estimating pup mortality. Timing of the census is critical since pups range further as they get older, and once pups molt (in late February) they begin spending increasing portions of their time in the water. Ideally pup counts should be conducted within several weeks of the termination of pupping. Tradeoffs exist, however, since the earlier the census is conducted, the more likely counters will encounter aggressive animals that prevent enumerating sections of a colony or, at the very least, aggressive behavior towards counters causes inaccuracies in counts. Once pups begin to molt into adult pelage (approximately ten weeks old) they are much more mobile and spend more time swimming offshore of colonies making it difficult to make an accurate census. This census began 20 days after the last pups were born at Cape Shirreff and before the median age of pups was eight weeks. The median date of pupping at Cape Shirreff in 2001/02 was 7 December (Goebel *et al.*, 2002). Assuming that other colonies in the South Shetlands had a similar distribution and median date of pupping, the median age of pups would thus have been between 55-61 days (or ~8 weeks) at the time of the census. Thus, the timing of our census minimized errors associated with seasonal changes in the distribution of animals.

Pup mortality and the error associated with it for censusing colonies are less tractable than pup behavior and timing of the census. In this study, we demonstrated that a single dead pup count at the time of a colony survey leads to an underestimate of pup mortality and total pups born. For example, when dead pups were counted daily at our sample colony, the cumulative mortality by the end of the pupping period was 52 pups. When we censused the same area 19 days later, the mean number of dead pups counted by three observers was 13. Counting the number of dead pups visible in late January/early February at our sample colony underestimated pup mortality by 75%. If we assume a similar rate of underestimating for all colonies, our mean total dead pup count of 138 would represent an actual on land mortality of 552 pups. Thus, our estimate of 10,057 (±141) can be considered a minimum number of pups born.

There is, however, yet another significant source of pup mortality that was not measured in this study. Our study only measured *on land* mortality. Leopard seal predation on fur seal pups, once they begin entering the water at approximately one month old, represents a significant source of mortality that is not possible to estimate by single visits to colonies to count pups. It has, however, been documented and measured at Seal Island, one of the colonies in the Elephant Island group (Boveng *et al.*, 1998). In that study, which took place from 1986-1995, leopard seal mortality was calculated to range from 32-69% of total pups born. They hypothesized that leopard seal predation may be regulating recruitment and preventing recovery of fur seals to pre-exploitation (i.e. pre-1820's) levels (Boveng *et al.*, 1998). They provided three conceptual models of leopard seal predation that described the impact of predation given various criteria and assumptions. One of their models describes predation mortality as density dependent at low densities of prey (i.e. fur seals) and inversely density dependent at moderate to high densities, producing a stable, low-density equilibrium or "predator pit" that prevented further recovery. The North Cove colony, however, was not at equilibrium as the number of pups declined from 239 to 197 pups born during the years that they quantified predation. Our census of North Cove revealed that the decline that they documented has continued since only 15 pups were counted. Two of the counters in our team had had previous experience working with the Seal Island population and noted that the densities of adult animals on shore at north cove indicated that much of the decline was likely due to an increase in predation. This observation was further supported by the fact that two other colonies at Seal Island, North Annex and "Big Boote" had substantial increases in pup production (16.7% and 84%, respectively, since the 1994/95 census; Boveng *et al.*, 1998). The total number and presence of leopard seals does fluctuate both within a season and between seasons (Boveng *et al.*, 1998; Hiruki *et al.*, 1999) but during the years that they studied predation, the impact of predation was never what appears to have occurred at North Cove during the 2001/02.

The North Cove colony at Seal Island is unique in that the colony has an extensive deep but calm pool that is protected from surf that fur seal pups have access to at an earlier age than at other sites. It also has a channel relatively protected from surges and surf that allows leopard seals, at all but the lowest tides, access to pups at a younger age (at least compared to other sites). Thus, fur seal pups at this site may be more vulnerable to leopard seal predation. Whether predation at other sites is only delayed, or delayed but mitigated by older pups being less naïve, is not known and was not addressed in their study. Top-down regulation of marine mammal populations has been recorded in other ecosystems. Estes *et al.*, (1998) provided evidence that Orca whale predation was responsible for recent declines in sea otter populations in the Aleutian Islands. They also showed with modeling of predator/prey numbers and energetic considerations of the predator that surprisingly few individual predators could account for significant declines. Leopard seals, preying on juveniles instead of all age classes (as is the case with sea otter/killer whale), may nonetheless, be responsible for limiting recovery of fur seal populations by limiting recruitment. This possibility warrants further study, particularly if leopard seal populations have increased or are increasing in the Antarctic Peninsula region.

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Table 7.1. Results of a pre-census count of pups at a selected site at Cape Shirreff, Livingston Island providing an example of intra-observer variance in counting.

	Observer:								
	1			**2**			**3**		
Count	**Live**	**Dead**	**Total**	**Live**	**Dead**	**Total**	**Live**	**Dead**	**Total**
1	591	15	606	541	6	547	587	12	599
2	595	20	615	631	7	638	622	10	632
3	618	20	638	606	8	614	619	13	632
Mean:			**620**			**600**			**621**
S.E.:			9.53			27.23			11.00
Max. difference from mean:			2.96%			8.78%			3.54%
Difference from grand mean:			1.01%			2.25%			1.23%

Table7.2. South Shetland Islands Antarctic fur seal pup census sites, locations, dates of census and weather at the start of each site census. Time represents the duration of the census in decimal hours.

#	Site Name	Lat	Long	Date	Census Start	Time (h)	Wind Direction	Wind Speed (km/h)	Air Temp. (°C)	Air Pressure (mm)	RH	PAR[1] Light	Visi-bility	Tide
Smith Island														
1	Cape Smith, Smith I.	-62.884	-62.284	31-Jan-02	03:30	1.55	44	4.0	2.5	1003	88	3	Exc	Low
Livingston Island Sites:														
2	San Telmo Islands	-62.468	-60.742	30-Jan-02	09:00	2.85	247	9.3	2.7	998	93	481	Exc	Low
3	Window Island	-62.577	-61.117	30-Jan-02	14:30	4.38	274	14.1	2.7	999	100	657	Exc	Low
4	Start Point	-62.577	-61.117	30-Jan-02	14:30	3.08	251	13.5	2.6	1000	100	345	Exc	Low
5	Desolation Island	-62.438	-60.314	31-Jan-02	11:50	1.27	235	4.7	2.7	1005	88	621	Exc	High
King George Island Sites:														
6	Fildes Peninsula	-62.196	-59.108	31-Jan-02	17:00	2.15	78	1.5	2.7	1006	92	328	Good	High
7	Stigant Point	-62.005	-58.858	1-Feb-02	04:16	2.28	56	13.4	1.7	1005	102	1	Fair	Med
8	Turret Point	-62.103	-57.895	4-Feb-02	07:15	1.88	275	14.7	4.0	995	93	156	Exc	High
9	Cape Melville	-62.043	-57.564	4-Feb-02	12:05	1.20	259	8.5	4.1	994	92	1186	Exc	High
Elephant Island Sites:														
10	Stinker Point	-61.270	-55.374	2-Feb-02	06:40	1.52	307	12.0	2.1	995	109	98	Fair	High
11	Cape Lindsey	-61.133	-55.529	2-Feb-02	09:35	4.25	308	13.6	2.6	995	109	428	Fair	High
12	Seal Island, Day 2	-60.991	-55.342	3-Feb-02	17:50	3.08	330	7.0	2.3	999	107	285	Good	High
13	Seal Island, Day 1	-60.989	-55.345	2-Feb-02	17:50	2.63	280	13.4	2.7	997	107	176	Good	Med
14	Cape Valentine	-61.127	-54.633	3-Feb-02	15:00	3.33	253	11.7	3.4	996	100	871	Exc	Low

[1] Photosynthetically available radius (PAR), a measure of light level.

Table 7.3. Pup production at Antarctic fur seal colonies in the South Shetland Islands, 2001/02. Sites are grouped by geographic proximity and by longitude (west to east). Each census was conducted with three to four counters from 30 January – 5 February 2002 and is presented with mean standard error (SE) and 95% confidence interval. ("n/c" indicates "not counted".)

Site Name	n[a]	LIVE Mean	LIVE SE	LIVE 95% CI	DEAD Mean	DEAD SE	DEAD 95% CI	TOTAL Mean	TOTAL SE	TOTAL 95% CI	% SSI[b] Total
Smith Island											
Cape Smith, Smith I.	4	7	0.00	-	0	-	-	**7**	0.00	-	0.07
Livingston Island Sites:											
Start Point	4	150	4.36	8.54	0	0.25	0.49	**150**	5.22	9.03	1.49
Window Island	4	393	13.54	26.54	5	0.91	1.79	**398**	16.83	27.95	3.95
San Telmo Islands:											
North San Telmo	3	1307	130.44	255.65	40[c]	-		**1347**	130.44	255.65	13.39
South San Telmo	3	774	15.53	30.45	3	0.33	0.65	**777**	15.77	30.91	7.73
San Telmo Islands, TOTAL		2081	144.06	282.35	43	0.33	0.65	**2124**	144.16	282.55	21.12
Cape Shirreff	3	6372	46.61	91.35	81	5.70	11.16	**6453**	40.92	80.21	64.17
Black Point	3	3	-		1	-		**4**	-		0.04
Desolation Island	4	2	0.00	-	0	-	-	**2**	0.00	-	0.02
King George Island Sites:											
Fildes Peninsula	Z	0	-	-	n/c	n/c	n/c	**0**	-	-	0.00
Stigant Point	4	158	11.37	22.28	0	-	-	**158**	8.50	22.28	1.57
Turret Point	4	0	-	-	0	-	-	**0**	-	-	0.00
Cape Melville	Z	0	-	-	n/c	n/c	n/c	**0**	-	-	0.00
Elephant Island Sites:											
Seal Islands:											
Seal I., Site 1 ("North Cove")	4	15	0.25	0.49	0	-	-	**15**	0.29	0.49	0.15
Seal I., Site 2 ("North Annex")	4	94	4.65	9.11	2	0.00	-	**96**	4.16	9.11	0.95
Seal I., Site 3 ("Big Boote")	3	66	0.00	-	0	-	-	**66**	0.00	-	0.66
"Large Leap" Island	3	190	11.24	22.03	2	0.00	-	**192**	11.24	22.03	1.91
"Saddle Rock" Island	-	n/c (63)[d]	-		n/c	n/c	n/c	**63**[c]	-		0.62
Seal Islands, TOTAL		427	7.95	15.59	4	0.00	-	**431**	7.95	15.59	4.29
Cape Lindsey	3	141	0.33	0.57	1	0.00	-	**142**	0.58	0.57	1.41
Stinker Point	Z	0	-	-	0	-	-	**0**	-	-	0.00
Cape Valentine	4	186	4.18	6.06	2	0.00	-	**188**	3.09	6.06	1.87
Total South Shetland Islands		9919	154.24	302.31	138	5.36	10.51	**10057**	141.83	240.74	100.00

[a] The number of observers (counters) at each site. "Z" indicates a zodiac survey of the shoreline, conducted at sites where there were no known colonies.
[b] Percent of the total South Shetland Islands pup production.
[c] Single dedicated count by one counter. (At San Telmo North three people counted live and one person counted dead pups. All other sites each counter counted both live and dead pups.)
[d] Sea conditions prevented landing at "Saddle Rock" I. The value presented is an estimate based on a February 1996 census using average rate of decline of other Seal I. sites.

Table 7.4. A comparison of pup production numbers at Antarctic fur seal colonies in the South Shetland Islands over a 15-year period from 1986/87-2001/02. Percent annual rate of change between censuses is calculated. Values are for total pups counted (live and dead).

Site	1986/87[a]	1991/92[b]	Annual rate of change [%]	1993/94[c]	Annual rate of change [%]	1995/96[c]	Annual rate of change [%]	2001/02[d]	Annual rate of change [%]
Cape Shirreff, Livingston I.	718	2583	51.9	3474	17.2	4968	21.5	6453	5.0
San Telmo Islands	1875	2340	5.0	2973	13.5	2684	-4.9	2124	-3.5
Window Island	297	375	5.3	397[e]	2.9	418	2.7	398	-0.8
Start Point, Livingston I.	0	43	-	86[e]	50.0	129	25.0	150	2.7
Desolation Island	1	0		n/c		1		2	-
Stigant Pt., King George I.	157	134	-2.9	146[e]	4.5	158	4.1	158	0.0
Cape Valentine, Elephant I.	45	126	36.0	124	-0.8	185	24.6	188	0.3
Cape Lindsey, Elephant I.	203	227	2.4	296	15.2	325	4.9	142	-9.4
Seal Islands:									
Seal Island (all sites)	249	305	4.5	299	-1.0	283	-2.7	176	-6.3
"Large Leap" Island	275	258	-1.2	306	9.3	292	-2.3	181	-6.4
"Saddle" Rock & Cave	n/c	n/c	-	63	-	101	30.2	63[e]	-6.3
TOTAL	3820	6391	**13.5**	8164	**13.9**	9544	**8.5**	10035	**0.9**

[a] Source: Bengtson, J.L., L.M. Ferm, T.J. Härkönen, and B.S. Stewart. 1990. Abundance of Antarctic fur seals in the South Shetlands, Antarctica, during the 1986/87 austral summer. In: K.R. Kerry, G. Hempel, (eds). Antarctic Ecosystems: Ecological Change and Conservation. Springer-Verlag, Berlin. Pp. 265-270.

[b] Source: Croll, D.A., J.L. Bengtson, R. Holt, and D. Torres-N. 1992. Census of Antarctic fur seal colonies of the South Shetland Islands, 1991/92. In: J. Rosenberg and R. Hewitt (eds). AMLR 1991/92 Field Season Report. Administrative Report LJ-92-17. Southwest Fisheries Science Center, NOAA/NMFS, La Jolla, CA 92037.

[c] Source: Meyer, W.M., B.G. Walker, and R.S. Holt. 1996. Antarctic fur seal abundance and distribution in the South Shetland Islands, 1996. In: J. Martin (ed). AMLR 1995/96 Field Season Report. Administrative Report LJ-96-15. Southwest Fisheries Science Center, NOAA/NMFS, La Jolla, CA 92037.

[d] Mean values are reported for 2001/02: see table 7.2.

[e] Estimated values. 1993/94 estimates for Window I., Start Pt., and Stigant Pt. are based upon censuses before and after and assuming a constant rate of change. "Saddle Rock" and Cave estimate in 2001/02 is based upon the 1995/96 census and applying the average rate of change at other Seal Island sites that were counted.

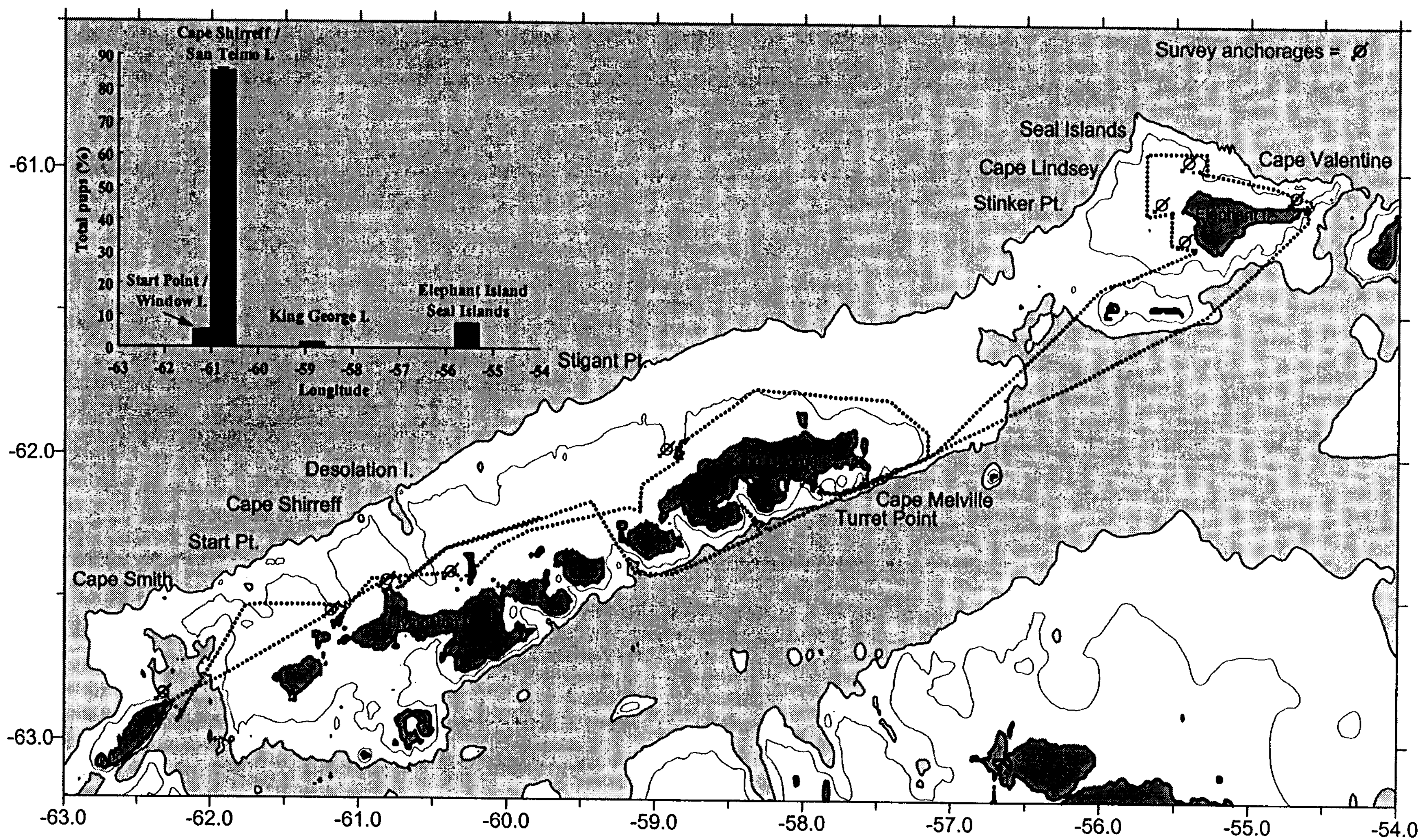


Figure 7.1. The study area, the South Shetland Islands, from Smith Island to Elephant Island. Islands are shown in dark gray, the continental shelf (to the 500m shelf break) is shown as white with a 250m contour line and a heavier line at 500m depth delineating the shelf edge. The survey ship's trackline is plotted as a dotted line. Anchorages (or sites where the ship hove to) are symbol labeled and an associated site name corresponding to each anchorage is printed just off the continental shelf from each site. The inset plot shows the percent total pup production by longitude for the entire archipelago.

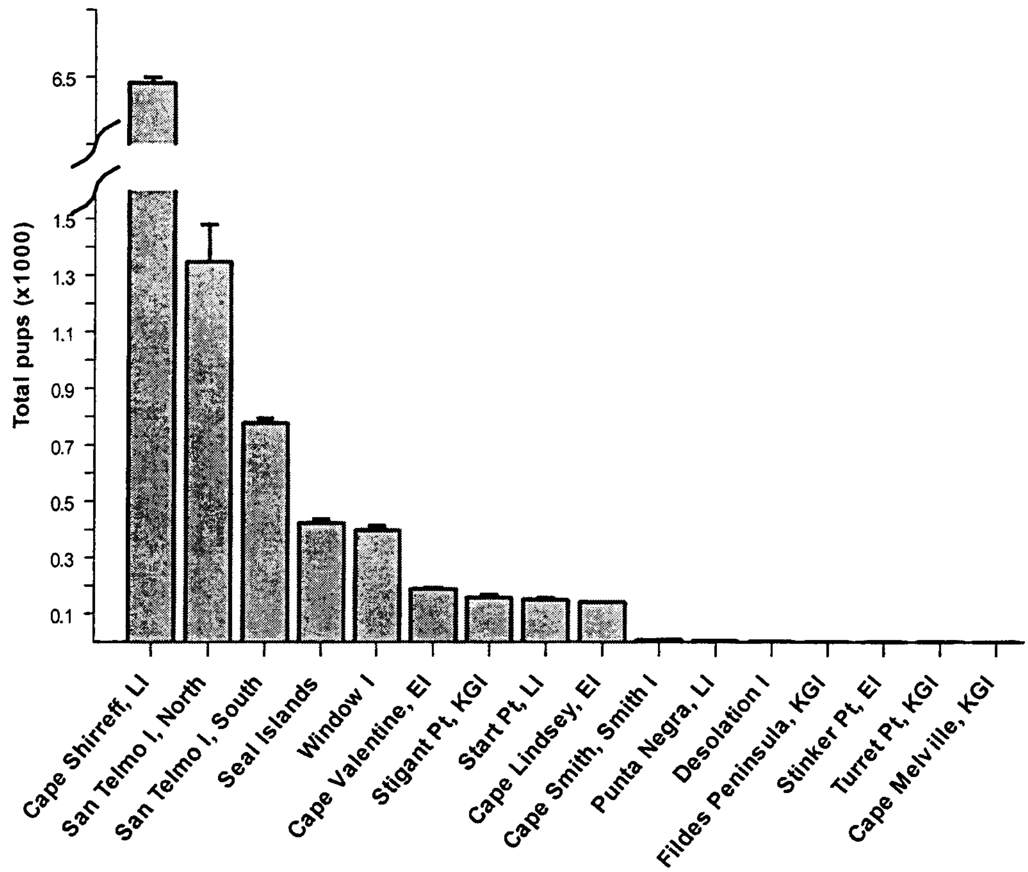


Figure 7.2. Total pup production by site in decreasing order of total pups born.

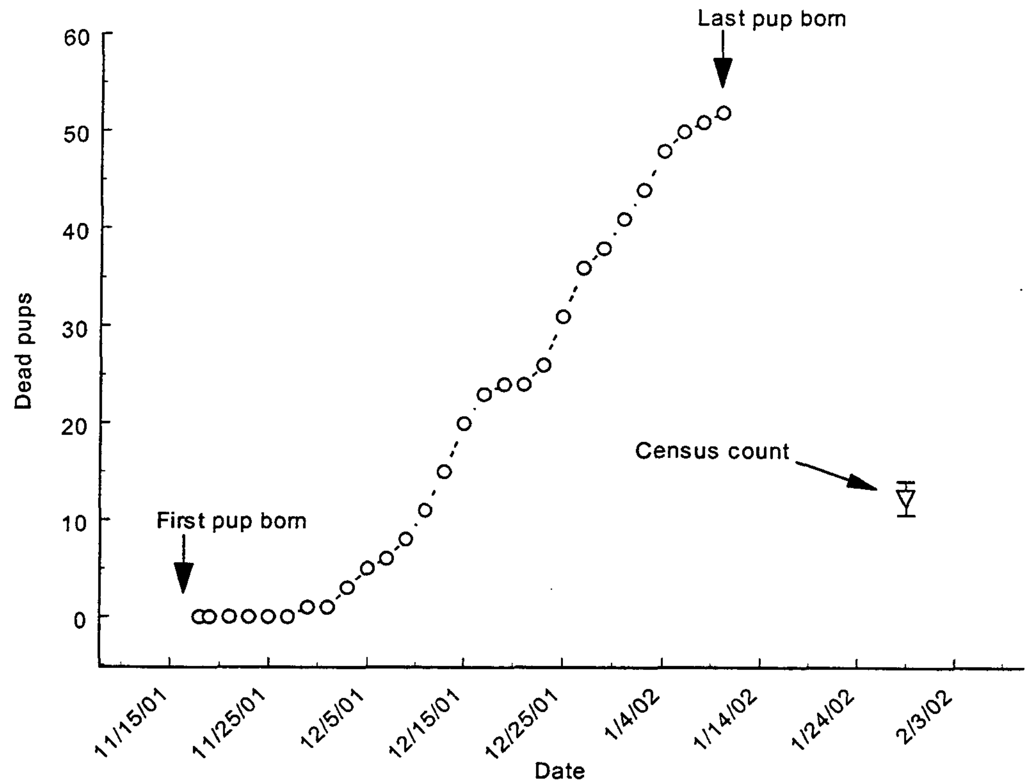


Figure 7.3. Cumulative pup mortality through the pupping period (18 November – 10 January) at a site on Cape Shirreff that accounted for approximately 10% of total pup production at Cape Shirreff. Live and dead pups were counted at this site around the start of the census (29 January) to estimate intra-observer variance. The mean number of dead pups counted on 29 January is plotted with standard error bars for comparison to total dead pups counted during the breeding season.

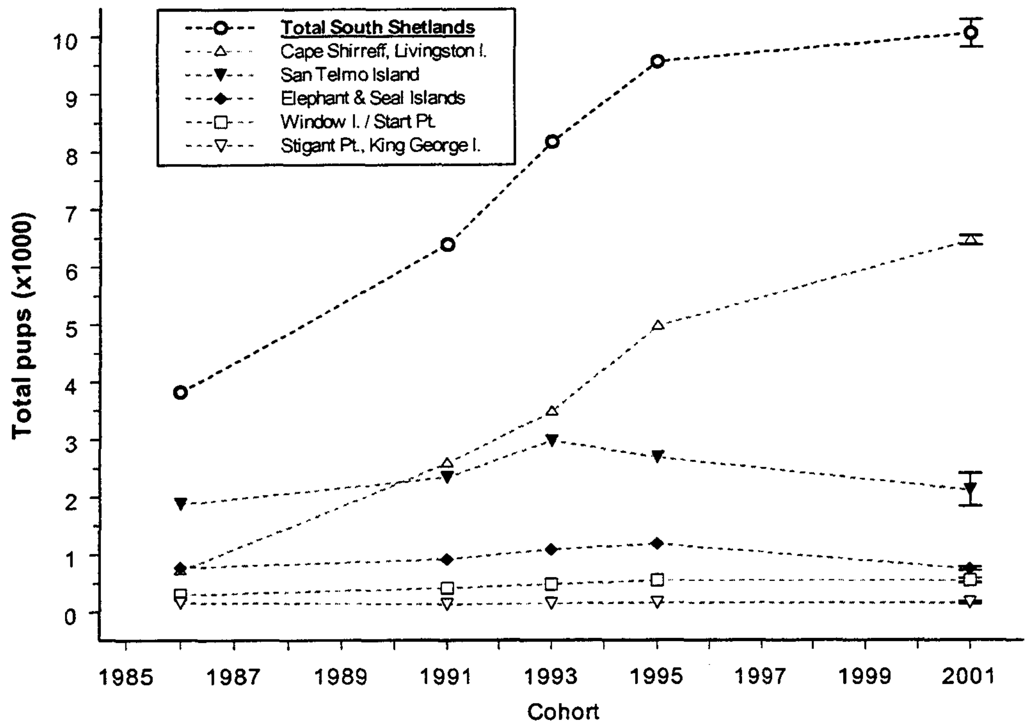


Figure 7.4. Total pup production over time from the 1986 cohort to the current census showing changes in the rate of pup production between censuses. The average annual rate of increase for fur seals in the South Shetlands has diminished to 0.9% per year since the 1995/96 census. This is down from ~13% per year up until 1993/94 and 8.5% from 1993/94 to 1995/96.

8. Near-Shore Acoustical Survey Near Cape Shirreff, Livingston Island; submitted by Joseph D. Warren (Leg II), Adam D. Jenkins (Leg II), and David A. Demer (Leg II).

8.1 Objectives: The near-shore area around Cape Shirreff serves as the main feeding ground for the seasonally resident fur seal and penguin populations at Cape Shirreff. These animals feed primarily on Antarctic krill, which aggregates in large swarms and layers in the waters just offshore of the island. Shallow and highly variable bathymetry makes this area unsuitable for study from large ships. Using a specially modified 19-ft zodiac (R/V *Ernest*), the near-shore region was surveyed, collecting acoustical backscatter and meteorological data. During this time, the R/V *Yuzhmorgeologiya* conducted a complementary offshore survey of the area (Figure 8.1). This survey overlapped coverage with that of *Ernest* and at the same time collected physical oceanographic, meteorological, and net tow data. All of these data sets were analyzed to study the relationships between the oceanography and biology of the area. Additionally, both ships collected bathymetric data for this region to investigate the presence and effect of two large submarine canyons that flank Cape Shirreff.

8.2 Methods and Accomplishments: Approximately 150 n.mi. were surveyed using *Ernest* from 17 to 23 February 2002 (Figure 8.1). *Ernest* is a Mark V 19-ft zodiac powered by two outboard engines: a 9.9-hp Yamaha and a 55-hp Johnson (Figure 8.2). The boat was equipped with radar, multiple GPS, EPIRB, VHF radio, a WeatherPak 2000 meteorological station (measuring temperature, humidity, barometric pressure, bearing and apparent and true wind speed and direction), and a 120kHz Simrad EY500 echosounder. A graphical user interface and logging program was written in Matlab by Joseph D. Warren to log and display all of the environmental parameters and chart *Ernest's* position in real-time (ErnieView). The split-beam echosounder transducer was deployed from the port side on a moveable arm. The system can be raised out of the water for quicker transit or rough sea state. There is also a downrigger that can be used to deploy additional instrumentation such as a small CTD or video camera system. *Ernest* runs from a bank of four gel cell batteries that can provide up to 20 hours of continuous power, providing 120-VAC power for data logging computers and instrumentation. The boat was also equipped with a survival and tool kits, manual and automatic bilge pumps, three survival suits, four fuel tanks, binoculars, and anchorage equipment.

Ernest was deployed from *Yuzhmorgeologiya* on 17 February 2002. First, the acoustical system was calibrated in approximately 30m of water near Cape Shirreff using a 38.1mm diameter tungsten carbide sphere. That afternoon and evening, *Ernest* was used to conduct a small-area survey of the eastern submarine canyon to locate a suitable mooring location for the multi-instrumented-buoy. Subsequent operations were based from the field camp on Cape Shirreff. The planned survey grid extended 10 n.mi. offshore from Cape Shirreff. Weather conditions were good during much of the survey period, allowing good (>60%) coverage of the grid. Strong winds (20-25-kts from the NW) and rough sea condition limited much of the survey west of Cape Shirreff. Typical survey speeds were 5-kts and an average of 6 hours per day were spent on the water. During *Ernest's* survey work, *Yuzhmorgeologiya* conducted a complementary survey grid, further offshore, but staying near *Ernest* in case of emergency. Once *Ernest* returned to shore at Cape Shirreff each afternoon, *Yuzhmorgeologiya* proceeded to conduct an offshore acoustical survey, collecting CTD and IKMT zooplankton samples during the return trip to Cape Shirreff the following morning (Figure 8.1). *Ernest* was brought aboard *Yuzhmorgeologiya* on the afternoon of 23 February 2002.

8.3 Results and Tentative Conclusions: Volume backscattering coefficient at 120kHz were integrated over the upper 100m of the water column and averaged over 0.1-n.mi. of survey distance (Sa). These Sa are believed to be proportional to the density of krill (Figure 8.3). As was seen in the 1999/00 survey effort, the highest concentrations of krill were found in the near-shore region southeast of Cape Shirreff. However, this year's survey also found high densities of krill in the near-shore region southwest of the Cape. Weather conditions and equipment malfunction prevented successful deployment of the video camera system, so the backscattering aggregations thought to be krill were not visually identified. However, based on the 1999/00 near-shore survey and the 2001/02 net tow data from *Yuzhmorgeologiya*, the acoustical targets are believed to be euphausiids *Thysanoessa macrura* and *Euphausia superba*. During the survey, penguins and seals were often seen foraging in areas with high acoustic backscatter.

Individual target strengths (TS) were analyzed from the EY500 data. Targets between 10 and 40m depth with along- and athwart-ship angles less than 3 degrees had a bimodal distribution (Figure 8.4a) with a major mode centered at approximately -68dB. This value is consistent with the results from the near-shore survey in 1999/00, and is believed to indicate that the scatterers are large krill (length >5cm). The higher TS values are likely from small fish. The distribution of target strengths versus depth of the scatterer was investigated (Figure 8.4b). Weaker targets were more likely to be found in shallower waters than stronger targets.

The results of the IKMT net samples show that juvenile krill had a higher concentration offshore (water deeper than 500m) while adults were more likely to be found in waters shallower than 500m (See section 3 in this report). The most abundant species at each station varied between juvenile and adult stages of *Euphausia superba*, *Thysanoessa macrura*, and *Euphausia frigida*. Copepods were also abundant and had a similar distribution to that of the krill. The distribution of *Thysanoessa macrura* appeared to follow the bathymetry of the region to some extent with higher densities of these animals found in regions in or near the two submarine canyons that flank Cape Shirreff (Figure 8.5).

The meteorological data collected by the WeatherPak 2000 system aboard *Ernest* shows that wind speeds were generally in excess of 5m/s. Wind direction was variably but most often from the NW (Figure 8.6). True wind speed and direction were calculated from the apparent wind speed and direction and the speed and course of the R/V *Ernest*. The humidity sensor often gave readings >100% and is believed to have a 10-15% offset. Temperature was generally 2°C, ranging from 3°C during brief sunny periods, to just below 0°C when the winds shifted to the south and blew cold air down from the glacier on Livingston Island. Compared to the meteorological data collected by *Yuzhmorgeologiya* (Figure 8.7), the near shore region surveyed by *Ernest* had much more variable wind speed and direction.

An analysis of the CTD and oxygen profiles collected from *Yuzhmorgeologiya* also shows a relationship between the physical oceanography of the region and the bathymetry, particularly the submarine canyons. Alongshore profiles show two elevated regions of temperature and oxygen in the near surface water, which may possibly be from Antarctic Circumpolar Current water that is upwelling through the submarine canyons. This water would provide oxygen to the near-shore region, which would stimulate primary and secondary production. This is a possible explanation for the elevated regions of acoustic scattering that were observed during this survey and why these particular near-shore regions are the primary foraging grounds for the penguin and seal populations of Cape Shirreff.

8.4 Disposition of Data: Data are available from David A. Demer, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA; phone/fax: +1 (858) 546-5603/5608; email: David.Demer@noaa.gov

8.5 Acknowledgments: We are indebted to the scientists and crew aboard R/V *Yuzhmorgeologiya* for keeping a watchful eye over R/V *Ernest* and crew, and for collecting CTD, acoustical, and net tow data during the survey. We would also like to thank the personnel of the Cape Shirreff field camp for their hospitality during our stay at their home. Under contract from the Advanced Survey Technologies Program at SWFSC, R/V *Ernest* was cleverly designed and solidly built by Leif Knutsen of Port Townsend Shipwrights, Inc. Joseph D. Warren was supported by Office of Naval Research grant #N00014-01-1-0166.

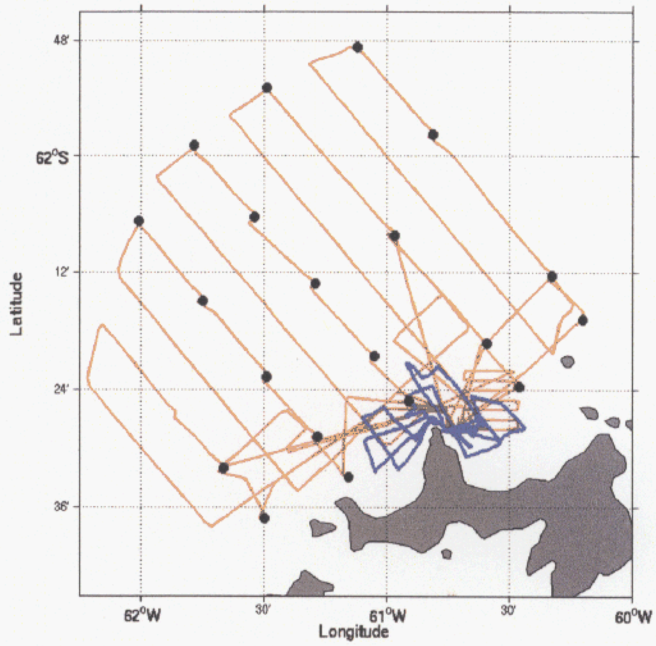


Figure 8.1. Completed tracklines of the R/V *Yuzhmorgeologiya* (red) and R/V *Ernest* (blue) during the 2002 AMLR near-shore survey of Cape Shirreff. Black dots indicate the locations of CTD and IKMT stations.

Figure 8.2. R/V *Ernest* moored at the protected beach immediately north of the Cape Shirreff field camp with the R/V *Yuzhmorgeologiya* in the background.

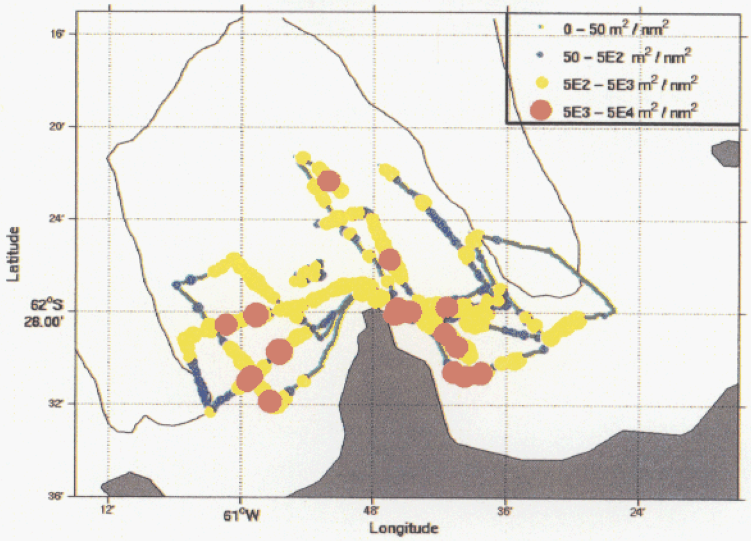
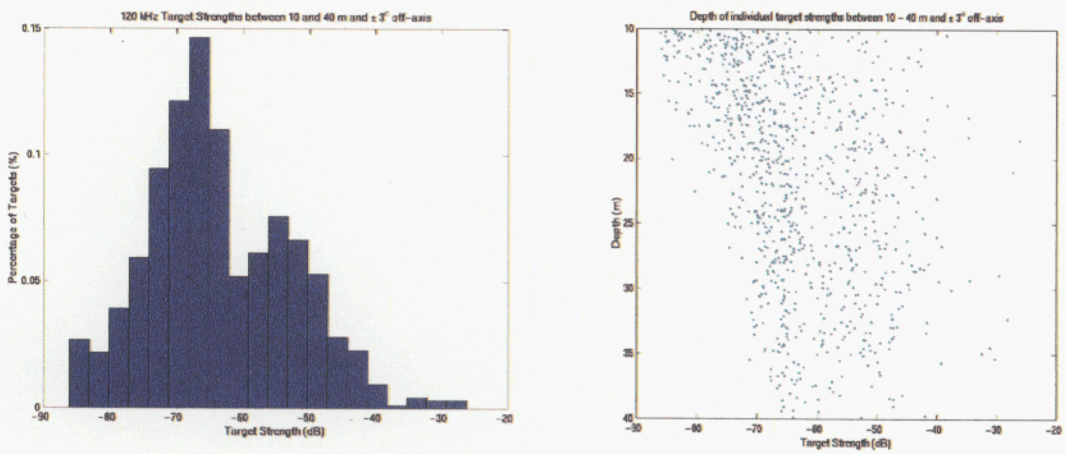


Figure 8.3. Volume backscattering coefficients at 120kHz integrated over the upper 100m of the water column and averaged over 0.1 n.mi. bins (Sa). Overall values of Sa are slightly lower than during the 1999/00 near-shore survey, however the highest Sa values of both years are very similar. Elevated backscatter (indicative of the presence of krill) occurred in the areas immediately east and southeast of Cape Shirreff and slightly further west of the Cape. The 200m isobath is shown in black showing the regions of highest scattering occurred near the heads of these two submarine canyons.



(a) (b)

Figure 8.4. (a) Histogram of individual target strength (TS) measurements at 120kHz collected by the split-beam EY500 echosounder. The peak value is at approximately -68dB which is similar to that found in the 1999/00 survey and corresponds to large krill. The second mode, centered around -50dB, is likely from small fish, possibly myctophids. (b) Distribution of individual target strengths with depth showing that stronger targets generally occurred in deeper waters. However this may be an artifact of multiple targets incorrectly being resolved as a single target by the echosounder.

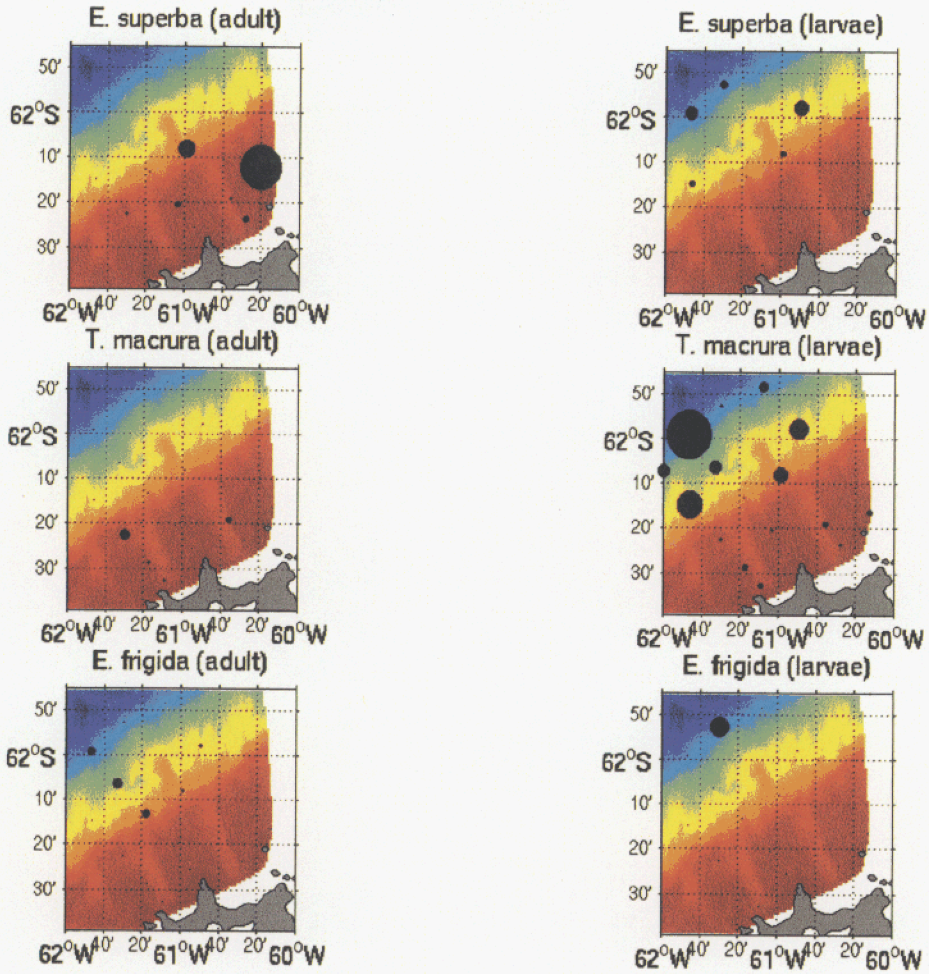


Figure 8.5. Distribution of euphausiids from IKMT new samples collected by the RV *Yuzhmorgeologiya* during the 2001/02 near-shore survey overlaid on a bathymetry map (red = shallow, blue = deep). The largest black circles correspond to numerical densities of 6 animals per m^3. The diameter of the other black circles is linearly proportional to the numerical density. Animals were more abundant off-shore than near-shore, however the distribution of *Thysanoessa macrura* show increased numerical densities on and near the submarine canyons flanking Cape Shirreff.

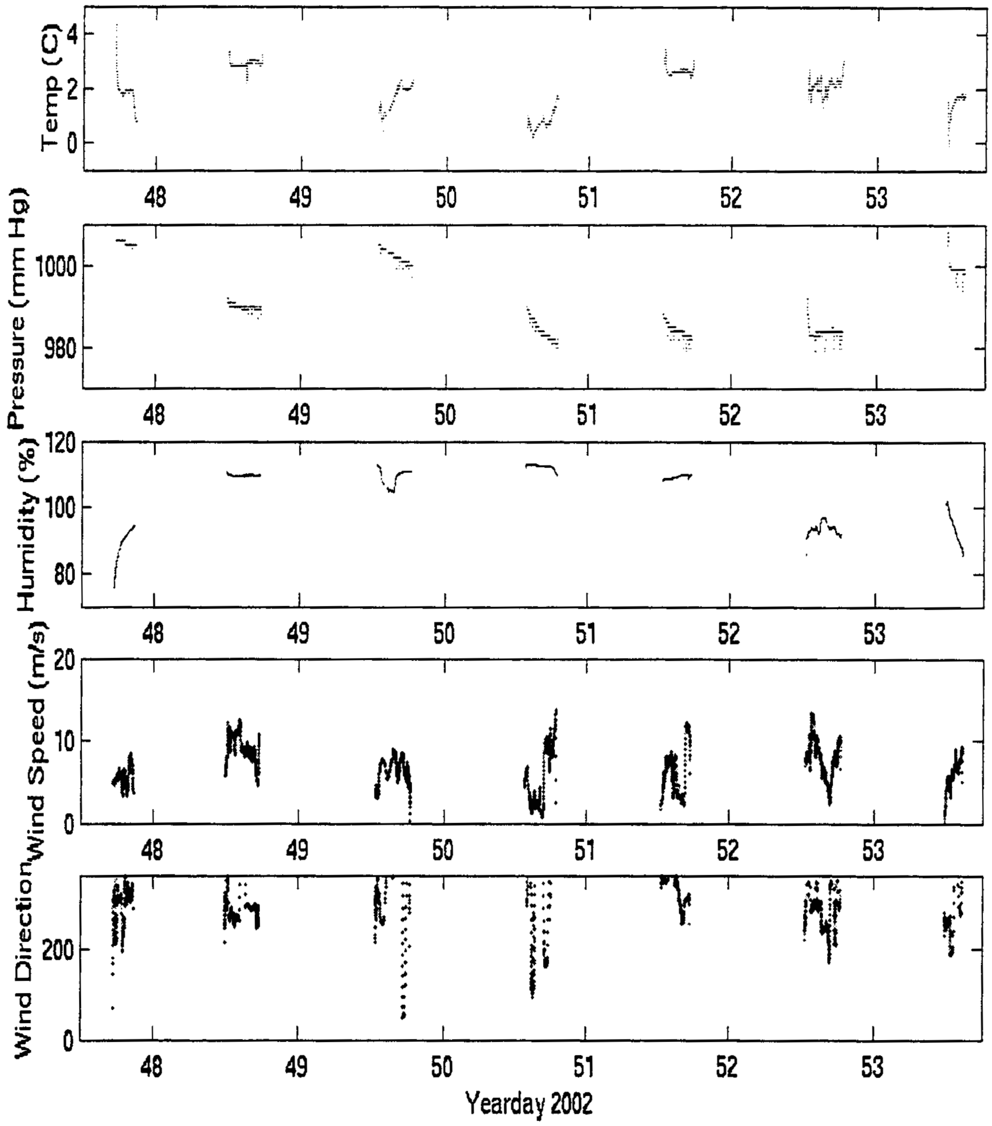


Figure 8.6. Meteorological data from R/V *Ernest* during the near-shore survey. The humidity sensor readings are likely offset 10-15% high. Wind speed was generally higher than 5m/s with a peak gust recorded of 18m/s. Most frequent wind direction was from the NW.

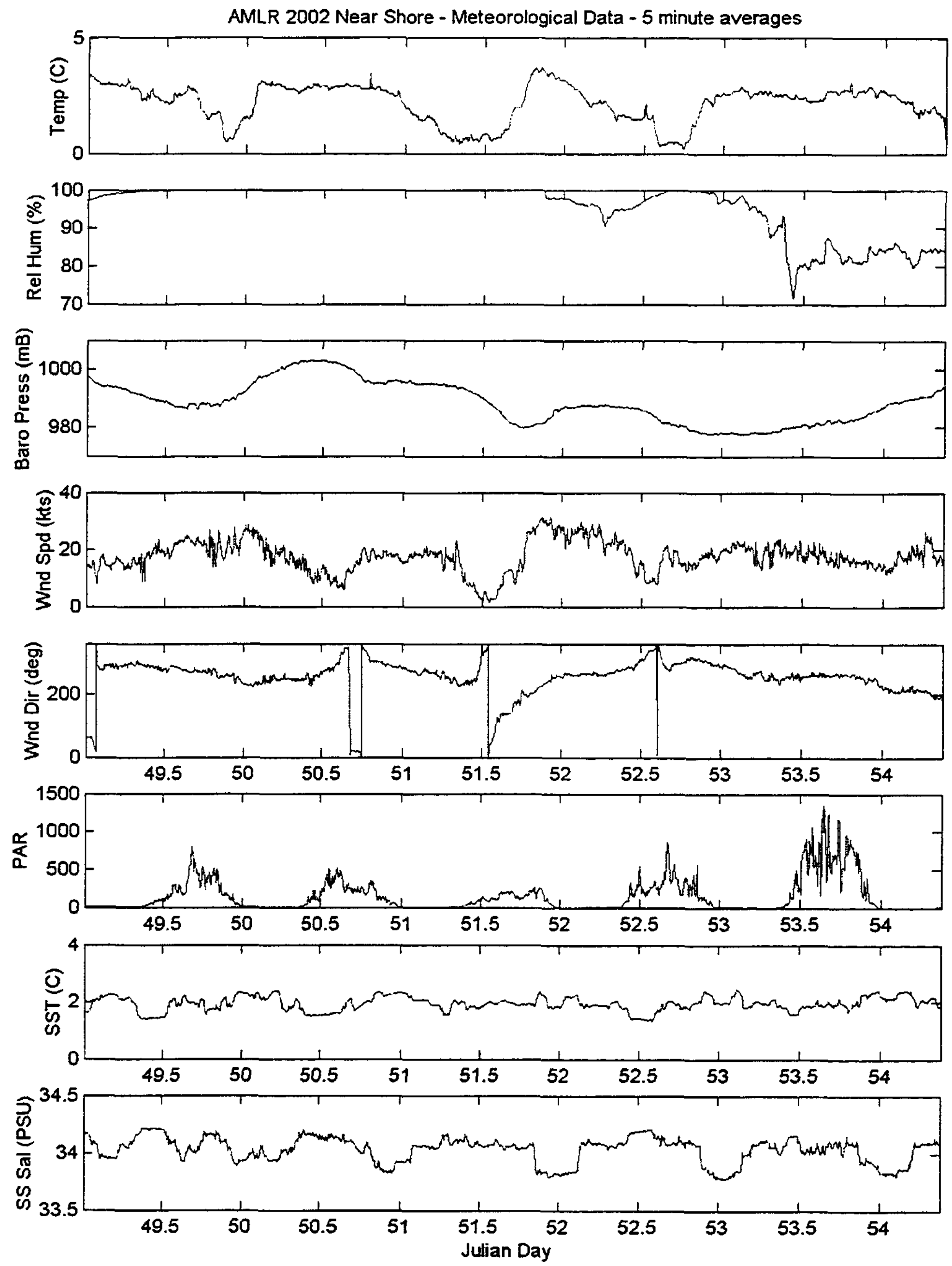


Figure 8.7. Meteorological data from R/V *Yuzhmorgeologiya* during the near-shore survey. PAR is photosynthetically absorbed radiation. SST is sea surface temperature.

9. Total target strength measurements of Antarctic zooplankton and nekton; submitted by Stephane Conti (Leg II) and David A. Demer (Leg II).

9.1 Objectives: Measure total target strength (*TTS*) over a wide acoustical bandwidth for multiple species of Antarctic zooplankton and nekton. These experiments are preliminary to the development of an improved classification method for the three-frequency echo sounder data.

9.2 Methods and Accomplishments: *TTS* was measured for multiple species using a new technique first described by De Rosny and Roux (2001). In this application, 200 sound pulses at each frequency (36-202kHz) were sequentially transmitted into a highly echoic tank containing swimming animals of a single species. For each pulse, the animals took different positions within the fixed-boundaried-tank and the modulated reverberation was recorded. The coherent energy in 200-pulse ensembles identified sound scattered from the echoic tank. Because the positions of the animals were uncorrelated from ping-to-ping, the incoherent energy described sound scattering from the animals. Thus, the *TTS* at each frequency was extracted from an analysis of the coherent and incoherent energy reverberated in the tank. Previously, Demer and Conti *et al.* (submitted) used precision metal spheres to demonstrate that the method has potential for remarkable accuracy (0.4dB) and precision (±0.7dB).

The experimental apparatus included: a computer, arbitrary waveform generator, power amplifier, wide-bandwidth transducer used as an emitter, three omnidirectional hydrophones, an analog-to-digital converter, a digital thermometer, and three glass carbuoys (volumes = 9.3, 19.3, and 45.9 liters), as shown on Figure 9.1. Carbuoys were used for echoic tanks so as to maintain fixed boundaries while operating on a moving ship. The choice of cavity volume depended on the numbers and sizes of animals available from the Isaacs-Kidd Midwater Trawl (IKMT) catches.

To make *TTS* measurements, a carbuoy was filled with seawater, then the live animals, and closed with a rubber stopper holding the transducer, three hydrophones, and a thermocouple (Figures 9.2A & C). For each frequency from 36 to 202kHz, the computer generated a chirp signal with 0.5ms duration. The signals were sequentially transferred to the arbitrary waveform generator that repeated each 2kHz-bandwidth chirp 200 times at a 0.5-Hz repetition rate. The amplified signals were transmitted into the carbuoy; reverberation time-series were simultaneously received by each of three hydrophones, digitized at 410kHz, and stored on hard disk. All of the experimental data were saved on hard disk for analyses and then compressed and stored on compact disk for archive.

As these were the first *TTS* measurements to be made in the field, the measurements were baselined without the motion and noise of the ship. From 18 to 22 February, the first ever *TTS* measurements of krill were thus made at the Cape Shirreff field station. Each morning, krill captured with the IKMT were transferred ashore via zodiac in 20-l buckets of seawater and other assorted containers. Depending upon the supply, groups of 57 to 1,169 krill were then moved into 9.3, 19.3 or 45.9-l glass carbuoys for the *TTS* measurements. Following the acoustical measurements, animal lengths were measured to the nearest millimeter before preserving them in sample jars with ethanol. At the conclusion of the near-shore survey operation, *TTS* measurements continued aboard R/V *Yuzhmorgeologiya* throughout the remainder of Leg II. More krill data were acquired, as well as data from myctophids, a squid, and *Cyllopus* spp.

9.3 Results and Tentative Conclusions: The measurements were focused on Antarctic krill (*Euphausia superba*, Figure 9.2B), with some *TTS* measurements made of myctophids (*Electrona antarctica*, Figure 9.3*; Gymnoscopelus braueri*, Figure 9.4*; and Gymnoscopelus nicholsi*) and *Cyllopus* spp. and a squid (Figure 9.5). The mean *TTS* of *E. superba* were realized with 57 to 1,169 krill per carbuoy (Figure 9.6). The groups of krill had a variety of length-frequency distributions (Figure 9.7) having an overall average length of 31.6mm. After low-pass filtering the reverberation time-series, the *TTS* measurements of krill made shipboard were favorably compared to those made at Cape Shirreff. The *TTS* measurements of krill at frequencies below about 60kHz had an increased standard deviation (sd). Therefore, the elevated mean values at those frequencies may not be accurate. Additional analysis of the data from the 13mm diameter copper calibration sphere may help to validate those measurements.

The *TTS* and mean *TTS* of *E. antarctica* were recorded from single myctophids and groups of up to four fish (Figure 9.8). Again, some of the *TTS* measurements below about 60kHz were elevated and had large standard deviations. The mean *TTS* of a single squid was also estimated from four wide-bandwidth runs (Figure 9.9). A comparison of the mean *TTS* measurements for krill, myctophids, and squid (Figure 9.10) shows distinctly different scattering spectra for these three taxa. Although the slopes of *TTS (frequency)* are similar, the amplitudes are separated by about 5 to 20dB. This degree of separation should be sufficient to acoustically delineate the three scattering taxa.

Some of the *TTS* measurements were not accurate because the subjects were not adequately moving. The *TTS* of *Cyllopus* spp. are not reported because their scattering cross-sections were too small to be accurately measured with the method as implemented. The remaining measurements were deemed of good quality (Table 9.1), bar an increased standard deviation for some measurements below about 60kHz.

9.4 Disposition of Data: Data are available from Stephane Conti and David Demer, Advanced Survey Technologies Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037; phone/fax: +1 (858) 546-5691/5608; Stephane.Conti@noaa.gov; David Demer, phone: +1 (858) 546-5603; David.Demer@noaa.gov.

9.5 Acknowledgements: We are especially thankful to the Captain and all crew members of R/V *Yuzhmorgeologiya*, and to all the members of the zooplankton team (Nancy Gong, Emma Bredesen, Shelly Peters, Lorena Linacre-Rojas, Mike Force, Adam Jenkins, Valerie Loeb, and Rob Rowley) for providing us with live animals from the IKMT catches. Thanks to Rennie Holt for allowing us to conduct the experiments at both Cape Shirreff field station and aboard the ship, and to Rob Rowley for designing and constructing a very useful equipment rack for transporting the electronics to and from the island. Finally, thanks to the team at Cape Shirreff (Iris Saxer, Brian Parker, Dana Scheffler, Wayne Trivelpiece, and John Lyons) for their hospitality during our stay.

9.6 References:

De Rosny, J., and Roux, P. 2001. Multiple scattering in a reflecting cavity: Application to fish counting in a tank. *Journal of the Acoustical Society of America* 109:2587-2597.

Demer, D.A., Conti, S., De Rosny, J., and Roux, P., submitted. Absolute measurements of total target strength from reverberation in a cavity. *Journal of the Acoustical Society of America.*

Table 9.1 Total target strength measurements by species, date, and carbuoy volume.

Euphausia superba

Good	Date	Loc	Vol (l)	Num	Pings	Freq (kHz)	RX(s)	# RX	Rec (ms)	fs (kHz)	W temp.
	21802	C.S.	19.3	10	200	36:2:110	ITC1042	1	32	500	
	21802	C.S.	19.3	10	200	36:2:202	ITC1042	1	32	500	2.9
	21802	C.S.	9.3	2	200	36:2:202	ITC1042	1	32	500	3.5
	21902	C.S.	9.3	26	200	36:2:202	1042&4013	2	32	500	1.6
	21902	C.S.	9.3	5	200	36:2:202	Reson 4013	3	32	410	2.7
X	22102	C.S.	9.3	302	200	36:2:202	Reson 4013	3	20	410	3.6
X	22202	C.S.	9.3	100	200	36:2:202	Reson 4013	3	20	410	1.6
	22202	C.S.	9.3	50	200	36:2:202	Reson 4013	3	20	410	2.3
	22202	C.S.	19.3	30	200	36:2:202	Reson 4013	3	30	410	3.2
X	22302	C.S.	9.3	60	200	36:2:202	Reson 4013	3	20	410	3.4
X	22402	C.S.	19.3	60	200	36:2:202	Reson 4013	3	20	410	4.0
X	22602	Yuz	49.7	1169	200	36:2:202	Reson 4013	3	32	410	3.7
X	22702	Yuz	19.3	326	200	36:2:202	Reson 4013	3	20	410	2.0
X	30802	Yuz	19.3	258	200	36:2:202	Reson 4013	3	10	410	0.6
X	30802	Yuz	9.3	152	200	36:2:202	Reson 4013	3	10	410	2.5
X	30802	Yuz	9.3	86	200	36:2:202	Reson 4013	3	10	410	3.4
X	30902	Yuz	19.3	173	200	36:2:202	Reson 4013	3	10	410	1.4
X	30902	Yuz	9.3	176	200	36:2:202	Reson 4013	3	10	410	2.3
X	30902	Yuz	19.3	117	200	36:2:202	Reson 4013	3	10	410	3.1

Electrona antarctica

Good	Date	Loc	Vol (l)	Num	Pings	Freq (kHz)	RX(s)	# RX	Rec (ms)	fs (kHz)	W temp.
	22802	Yuz	19.3	3	200	38,70,120,200	Reson 4013	3	20	410	2.4
X	22802	Yuz	19.3	4	200	36:2:202	Reson 4013	3	20	410	2.4
X	30402	Yuz	19.3	3	200	36:2:202	Reson 4013	3	20	410	2.6
	30402	Yuz	19.3	3	200	36:2:202	Reson 4013	3	20	410	2.6
X	30502	Yuz	9.3	1	200	36:2:202	Reson 4013	3	10	410	2.2
X	30602	Yuz	9.3	1	200	36:2:202	Reson 4013	3	10	410	1.1
	30702	Yuz	9.3	1	200	36:2:160	Reson 4013	3	10	410	1.0
X	30702	Yuz	9.3	1	200	36:2:202	Reson 4013	3	10	410	1.5
	30802	Yuz	9.3	1	200	36:2:156	Reson 4013	3	10	410	1.7
X	30802	Yuz	19.3	1	200	36:2:202	Reson 4013	3	10	410	2.2

Gymnoscopelus nicholsi

Good	Date	Loc	Vol (l)	Num	Pings	Freq (kHz)	RX(s)	# RX	Rec (ms)	fs (kHz)	W temp.
	30602	Yuz	19.3	2	200	36:2:184	Reson 4013	3	10	410	1.2

Gymnoscopelus braueri

Good	Date	Loc	Vol (l)	Num	Pings	Freq (kHz)	RX(s)	# RX	Rec (ms)	fs (kHz)	W temp.
	30402	Yuz	19.3	3	200	36:2:202	Reson 4013	3	20	410	2.6
	30702	Yuz	19.3	1	200	36:2:174	Reson 4013	3	10	410	1.5

13mm diameter copper sphere

Good	Date	Loc	Vol (l)	Num	Pings	Freq (kHz)	RX(s)	# RX	Rec (ms)	fs (kHz)	W temp.
X	22102	C.S.	9.3	1	200	36:2:202	Reson 4013	3	32	410	10.3
X	31202	Yuz	19.3	1	200	36:2:202	Reson 4013	3	10	410	3.5

Empty Tank

Good	Date	Loc	Vol (l)	Num	Pings	Freq (kHz)	RX(s)	# RX	Rec (ms)	fs (kHz)	W temp.
	21702	C.S.	19.3	0	100	36:2:202	ITC1042	1	32	500	
	21702	C.S.	19.3	0	100	45:20:185	ITC1042	1	32	500	
	21802	C.S.	9.3	0	100	36:2:202	1042&4013	2	32	500	
	22002	C.S.	9.3	0	100	36:2:202	Reson 4013	3	32	410	10.2
X	22102	C.S.	9.3	0	100	36:2:202	Reson 4013	3	20	410	11.0
X	30202	Yuz	19.3	0	100	36:2:202	Reson 4013	3	20	410	3.0

Squid

Good	Date	Loc	Vol (l)	Num	Pings	Freq (kHz)	RX(s)	# RX	Rec (ms)	fs (kHz)	W temp.
X	30902	Yuz	9.3	2	200	36:2:202	Reson 4013	3	10	410	3.6

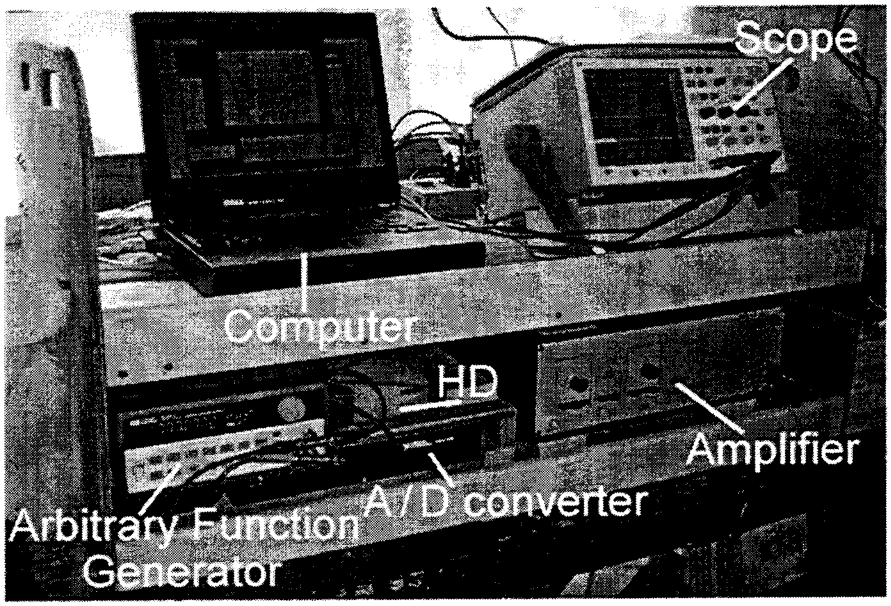


Figure 9.1. Experimental apparatus.

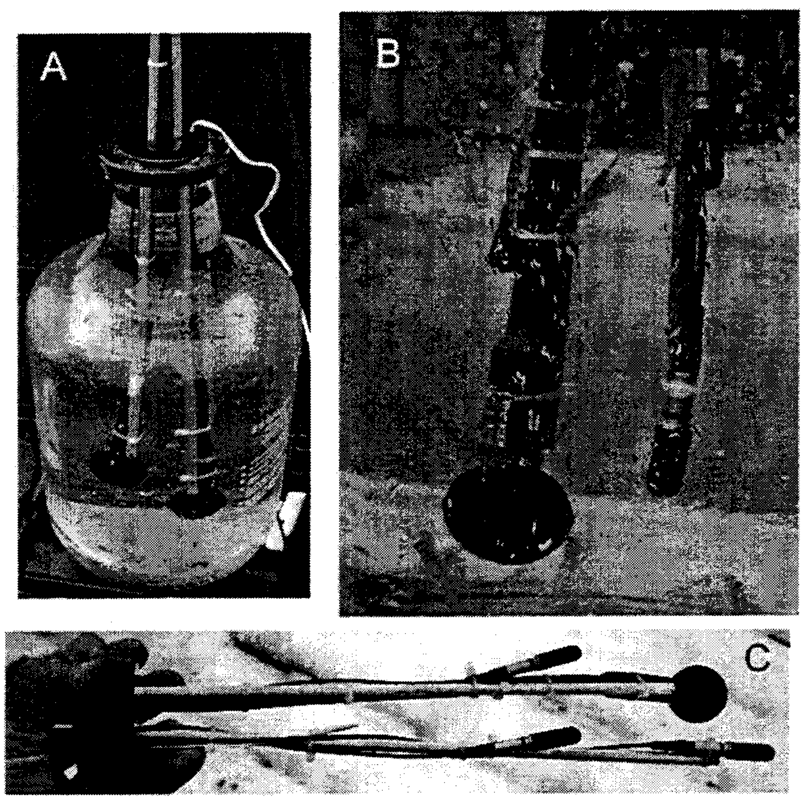


Figure 9.2. (A) 9.3-l carbuoy with transducer, hydrophone, thermocouple, and krill at Cape Shirreff field station; (B) *E. superba* in the 19.3-l carbuoy during the experiments aboard R/V *Yuzhmorgeologiya*; (C) and a rubber stopper fitted with the transducer (projector), three hydrophones, and a thermocouple.

Figure 9.3. *Electrona antarctica*

Figure 9.4. *Gymnoscopelus braueri*

Figure 9.5. The squid.

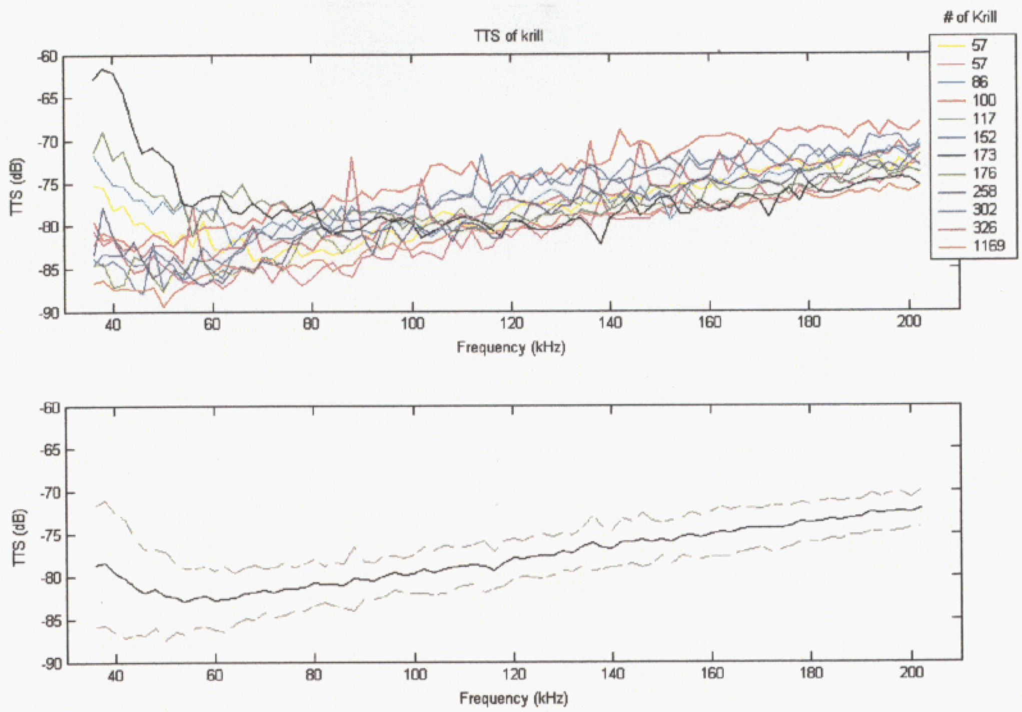


Figure 9.6. Mean *TTS* of *E. superba* measured from aggregations totaling 57 to 1,169 animals (top). The average of all runs is plotted with ±1 sd error bars (bottom).

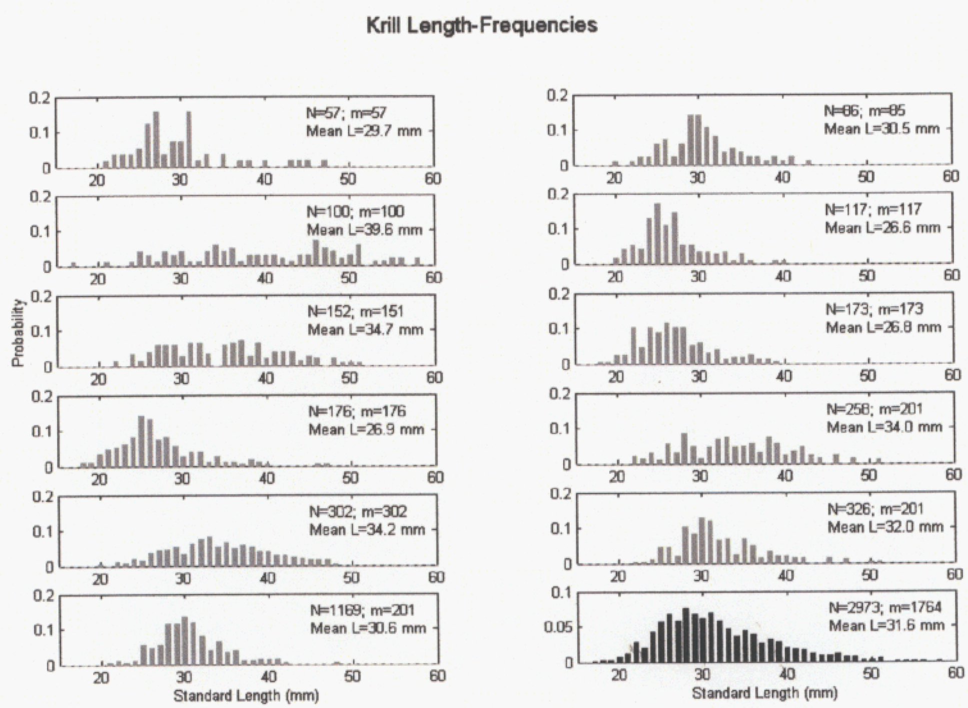


Figure 9.7. Krill length-frequencies are shown for each batch of krill measured (gray) and all of the krill combined (black).

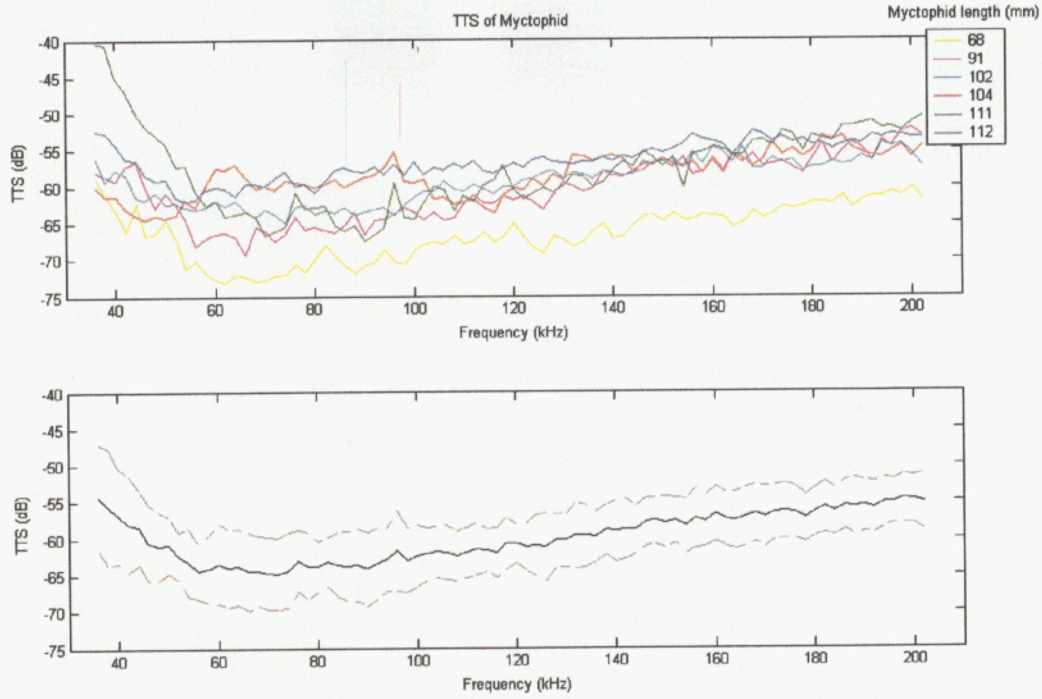


Figure 9.8. *TTS* and mean *TTS* of *E. antarctica* measured from individual fish and groups of up to 4 fish, respectively (top). The average of all measurements is plotted with ±1 sd error bars (bottom).

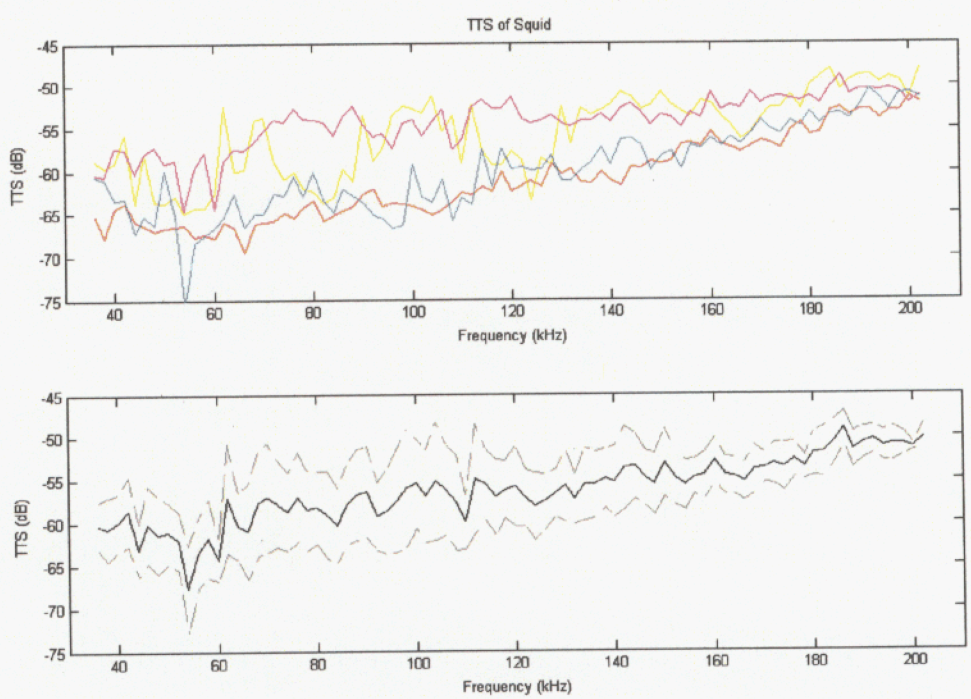


Figure 9.9. Mean *TTS* of a squid (top) estimated from the signals received at three hydrophones in each of four wide-bandwidth scans. The average of all measurements is plotted with ±1 sd error bars (bottom).

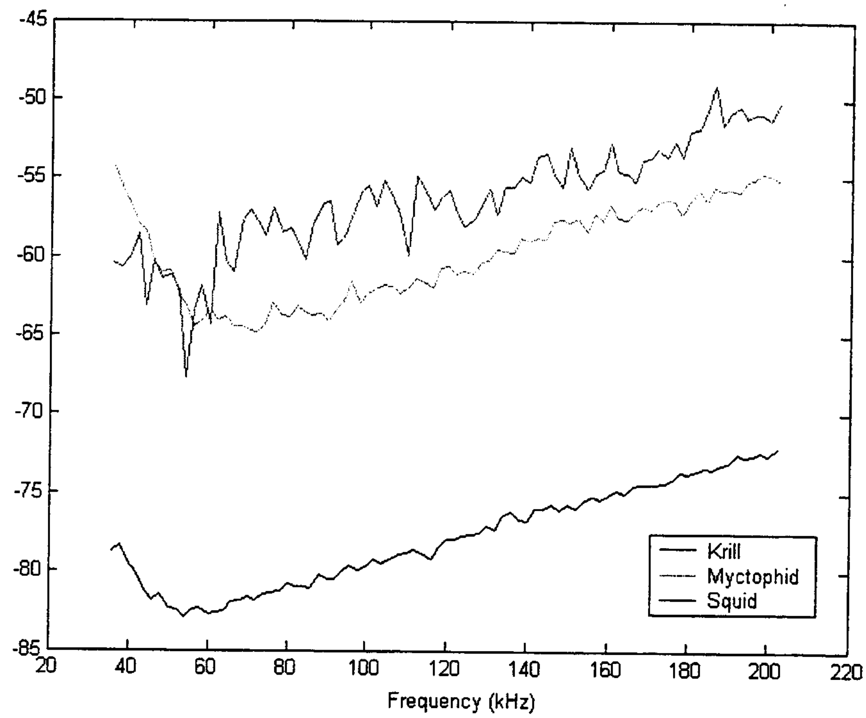


Figure 9.10. Comparison of the mean *TTS* of *E. superba, E. antarctica* and a squid.

10. Measuring krill abundance and current vectors using multi-instrumented remotely monitored buoys: submitted by David A. Demer (Leg II), Derek J. Needham (Leg II) and Michael A. Soule (Leg II).

10.1 Objectives: For over a decade, the Antarctic Treaty's Committee for the Conservation of Antarctic Marine Living Resources (CCAMLR) has been pioneering the ecosystem approach to fisheries management. The United States supports this international effort through the Antarctic Marine Living Resources Program (AMLR), managed at SWFSC, which aims to describe the functional relationships between Antarctic krill (*Euphausia superba*), their predators, and key environmental factors. AMLR's annual field studies include shipboard surveys of the meteorology, oceanography, phytoplankton, zooplankton and nekton around the South Shetland archipelago and a predator-monitoring base at Cape Shirreff, Livingston Island, Antarctica. The responses of land-based predators to changes in the availability of their food source are investigated. One challenge of this investigation is to temporally and spatially match the observations of predators and their prey.

10.2 Methods and Accomplishments: Multi-instrumented, remotely monitored, oceanographic buoys were developed to provide long time-series measurements of relative krill abundance in the near-shore area of Cape Shirreff. The Advanced Survey Technologies Program (AST) contracted Derek Needham and associates of Sea Technology Services to fabricate AST's concept for the lightweight, low-cost, spar buoys (Figure 10.1). One of the prototype buoys was fitted with a 300kHz acoustic Doppler current profiler to measure current vectors, acoustical volume backscatter, water temperature, pitch, roll, and bearing. Additionally, the buoys included a data logging computer, GPS, radar reflector, strobe, radio-modem, and power management circuit. Remote control of the instrumentation and real-time monitoring of data was accomplished by radio-telemetry between the buoy and a land-station. A second buoy was fitted with a Simrad ES60 dual-frequency echosounder (38 and 200kHz).

Two buoys were deployed in succession, approximately 5 n.mi. east of Cape Shirreff near the head of a submarine canyon (Figure 10.2). The mooring location was chosen for its consistent association with krill aggregations and predator foraging activities (See near-shore survey section in this report and in the AMLR 1999/00 Field Season Report). At 2200 on Sunday 17 February 2002, the ADCP Buoy was deployed over the stern of *Yuzhmorgeologiya* and towed to the mooring with a zodiac. The buoy appeared stable in the 1m swell. It stood upright, with the 20m tethering bridle preventing the wind from laying it over. There was about 30cm of freeboard on the electronics casing. The waves washed over the top of the electronics casing as predicted in the design; that was a good indication that the buoy was being effectively decoupled from the wave motion. The next morning, communications with the ADCP Buoy were established, from Cape Shirreff base, and a series of tests were performed. ADCP data was downloaded from the previous night and all appeared operational. The ADCP pitch and roll sensor showed movement of less than 10°. It was noted that on about 50% of startups, Windows 2000 read the GPS data as a PS2 serial mouse and took control of the Com port. At these times, the GPS data was not accessible and the mouse cursor made random movements. This problem was remedied with Windows 2000 Service Pack 2. On Saturday 23 February 2002, the ADCP Buoy was retrieved and the ES60 Buoy was deployed from the stern of *Yuzhmorgeologiya*, with assistance from a zodiac. The recovery went smoothly as the zodiac was able to keep the buoy away from the stern of the ship by maintaining tension on a towrope. The ADCP Buoy seemed in good condition and only paint chaffing was noticed around the top tethering point.

The ES60 Buoy was fitted with a Yuasa 12V 7Ah Gel battery and a 110V inverter to overcome unexpected problems of the 12V supply dipping during startup, precluding the echosounder from starting. This also helped to alleviate the problem of the echosounder shutting down at 11.8 VDC opposed to its specification of 11V. Operating with this ad-hoc solution, the ES60 Buoy was attached to the mooring when the ADCP buoy was recovered. The ES60 Buoy had less freeboard than the ADCP Buoy, settling with a waterline about 100mm below the top lid of the electronics case. The ES60 Buoy communicated with the shore station on time, but no GPS fix could be obtained. The ES60 was stopped (power still applied) and the system was left running for 30 minutes to see if the GPS would initialize itself. There seemed to be a problem with the GPS as no fix was obtained. There was power and communication with the GPS. Noise was also noted on the 38kHz trace, possibly from the inverter. At that time, it was also noted that the radio link was sluggish due to the frequent graphics update in the ES60 software. At 0700 on Sunday 10 March 2002 the ES60 Buoy was recovered after being deployed for 15 days. The buoy performed well in approximately 2 to 3m seas.

10.3 Results and Tentative Conclusions: Preliminary results have identified a variable shoreward current in the canyon, possibly causing episodic upwelling of deep water into the neritic zone. The biological scattering observed with the ADCP, possibly from krill, is high when the current is eastward or shoreward (ie. circa 12, 26, and 63hrs), and relatively low during the episode of westward and offshore currents (ie. 34-50hrs; Figure 10.3). Mid-morning each day, a light scattering layer is observed with the ES60 between approximately 5 and 60m (Figure 10.4). Around noon on the third day, the krill appear to descend to the seafloor. At approximately 1600 local time (GMT-3), a dense scattering layer appears between the surface and about 30m. A longer time-series for each of these data types would be very useful to characterize the temporal dynamics of prey behaviors and availability.

A relatively safe and cost-effective method has been developed for routinely and remotely monitoring the prey available to seals and penguins based at Cape Shirreff. The first deployments have garnered new information about the temporal variation in krill dispersion and possible environmental forcing.

10.4 Disposition of Data: Acoustical data from the ADCP and ES60 Buoys are available from David Demer, Advanced Survey Technologies Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, phone/fax: +1 (858) 546-5603/5608; email: David.Demer@noaa.gov.

10.5 Acknowledgements: We are very thankful to Rennie Holt for recognizing the value of a remotely monitored, multi-instrumented buoy array for monitoring oceanographic processes and krill availability in the penguin and seal foraging areas near Cape Shirreff. Moreover, we are thankful to Dr. Holt for funding this year's proof-of-concept endeavor. We are thankful to the Chief of deck operations aboard R/V *Yuzhmorgeologiya*, Oleg Lyaskovski, and to his crew for ably deploying and retrieving the buoys. Thanks also to Adam Jenkins and Rob Rowley for driving the zodiacs for those operations. In addition to Derek Needham from Sea Technology Services, special thanks go to his subcontractor, Mike Patterson, who performed the large majority of the buoy fabrication, in short order, and to Mike Berryman who programmed the buoy control software.

Figure 10.1. Multi-instrumented buoy deployed from R/V *Yuzhmorgeologiya*. The radar reflector, strobe and radio-modem antenna are visible at the top of the buoy's mast.

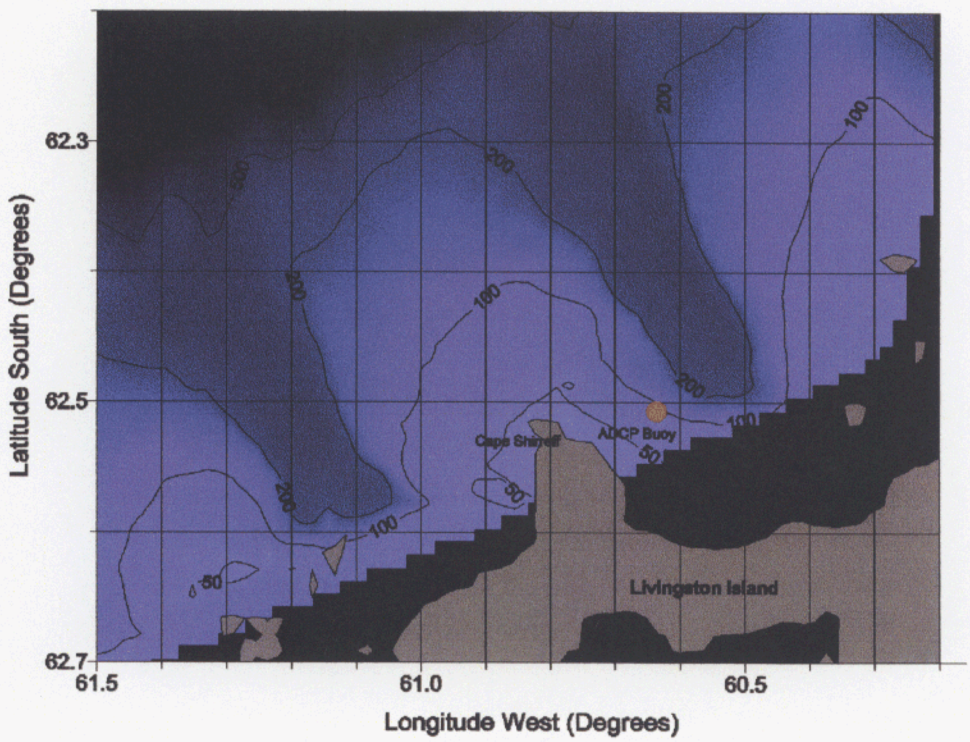


Figure 10.2. Buoy mooring location (red dot). Buoys were placed approximately 4.5 n.mi. to the east of Cape Shirreff field station and near the head of a submarine canyon.

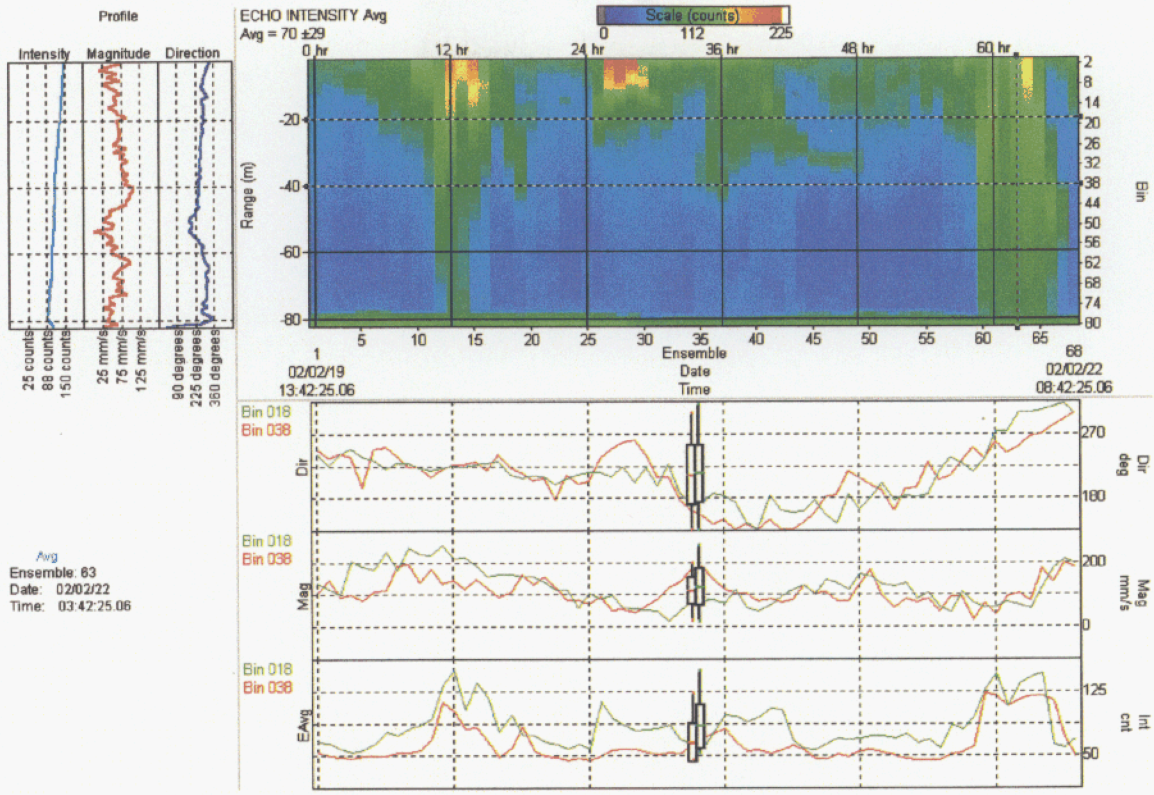


Figure 10.3. Sample profiles of echo-intensity, and current magnitude and direction (top left); echogram for the last three days of the ADCP-buoy deployment (top right); and time series of current direction and magnitude and echo intensity at 20 and 40m depths (bottom right). Note the diel fluctuations in the echo-intensity.

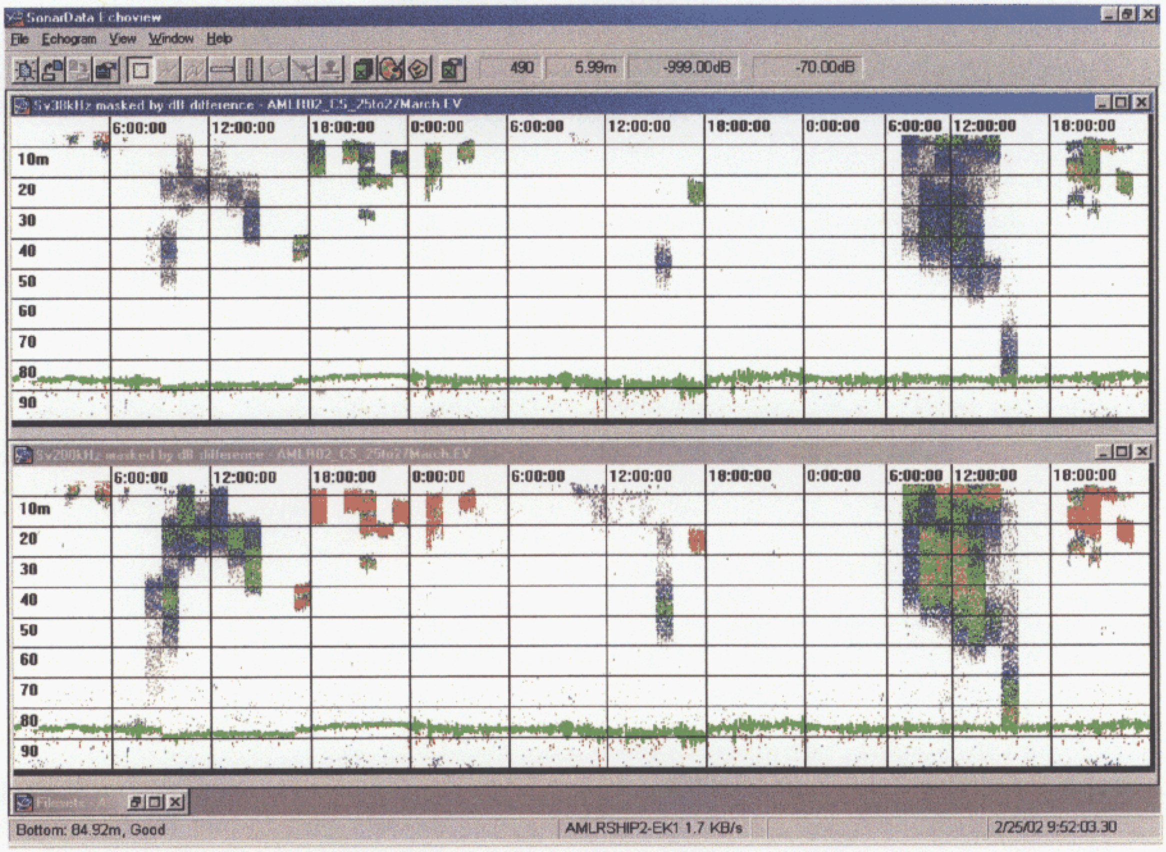


Figure 10.4. Resampled echograms (5 ping averages) from the ES60 echosounder operating at 38 (top) and 200kHz (bottom). The volume backscattering strength data (Sv) are displayed where $Sv_{200kHz} - Sv_{38kHz}$ is between 4 and 20dB. Thus, the scattering believed to be from krill is displayed for the three-day time-series (25-27 March).

11. Underway bird and mammal observations; submitted by Michael Force (Legs I & II).

11.1 Objectives: To obtain some understanding of mid- to late-summer seabird distribution, abundance, and habitat use in the pelagic waters of the Drake Passage and the neritic waters of Tierra del Fuego. Standardized data collection methodology will enable analysis of longer-term trends when combined with an existing data set encompassing transits from 7 AMLR field seasons.

11.2 Methods: Marine bird and mammal observations were conducted under suitable conditions throughout daylight hours during the transits between Punta Arenas and the AMLR study area. For the bird observations, an estimated 300 meter wide transect in a 90° quadrant on one side of the bow was used (Tasker *et al.,* 1984; van Franeker, 1994). Observations were made from either the bow or the bridge wing and consisted of a series of continuous 30 minute transects while the ship was underway on a constant speed and bearing. The strip transect was surveyed without binoculars. However, 10x40 binoculars were used regularly to scan the outer perimeter for cryptic species and to confirm species identifications. All the birds seen in the quadrant were recorded in two behavior categories, sitting or flying (combined in the analysis), and age was noted whenever possible. Ship followers were problematic and great care was taken to avoid recounts. Additional details included observation conditions, seastate and visibility. In contrast, marine mammal observations were conducted entirely on an opportunistic basis and lacked a dedicated and systematic search effort. Data collected included species identification, number of animals and any relevant behavioral/social information.

11.3 Accomplishments: Visual observation effort was possible during all days in transit: southbound 12, 13 January and 15, 16 February; northbound 9, 10 February and 13, 14, 15 March. The 2 southbound transits and the final northbound transit followed a similar route, while northbound at the end of Leg 1 was considerably farther west. Observations did not include the Strait of Magellan. Observation effort, dependent on favorable weather conditions, was not evenly distributed across all 3 strata. In total, 1,467 kilometers of trackline was surveyed during 65.6 hours of visual effort, recording 3,947 birds of 35 species. There were 31 marine mammal sightings of 8 species. An impressive concentration of feeding Fin and Humpback Whales was noted west of Aspland Island on 13 March.

11.4 Results and Tentative Conclusions: The route taken by the *R/V Yuzhmorgeologiya* during the transits traverse a broad range of seabird habitats. Because of this, the study area was stratified based on a combination of broadly applied geographical and physical considerations. The first stratum, Tierra del Fuego, is the neritic waters off the east side of Isla Grande de Tierra del Fuego south to about 55°30'S, and includes the bird-rich Estrecho de le Maire. The surface water is relatively warm with low salinity. Stratum 2, Northern Drake Passage, are pelagic waters from about 55°30'S to roughly the northern edge of the Polar Front. The surface water is colder than Stratum 1 with a higher salinity. Stratum 3, Southern Drake Passage, are the cold, lower salinity pelagic waters of the Polar front south to the AMLR study area. This provided an adequate working arrangement, even if there is some overlap, particularly in the mixing zone associated with the Polar Front.

Tables 11.1 to 11.4 summarize effort and sighting information. Thirty-four, 40 and 63 transects were completed in stratum 1, 2 and 3 respectively. Total number of species recorded in each stratum was similar with minor variations in species composition. Stratum 1, consisting primarily of coastal transects, had the highest number of species (24) and total individuals (2603). Sooty Shearwater accounts for almost 58% of this total. Ten or fewer individuals were seen for 58% of the species. Abundance and diversity declined south of the continent, with 17 and 22 species recorded in stratum 2 and 3 respectively. Moreover, 76% of the species in stratum 2 and 50% of those in stratum 3 recorded 10 or fewer individuals. On the other hand, 76% of the total birds seen in stratum 2 were prions. Fourteen species (40%) were recorded on at least 1 transect in all 3 strata while only 1 species, the Black-browed Albatross, occurs as one of the 3 most abundant species in every stratum.

There were several species seen this year not previously recorded on AMLR transits. Extremely far south of it's known range was the Stejneger's Petrel seen at 60°S in the central Drake Passage on 9 February. This species breeds only on Chile's Juan Fernandez Islands and ranges south to about 49°S (Enticott and Tipling, 1997). However, several beach derelicts have been recovered in New Zealand (Harrison, 1983). Careful elimination of the more likely but smaller Blue Petrel was based on previous experience with Stejneger's Petrel and differences in plumage and style of flight. A Cattle Egret in Estrecho de le Maire was also far south, although not as far south as those seen in the South Shetland Islands this field season. This species occurs regularly in the fall to Isla Grande de Tierra del Fuego (Fjeldså and Krabbe, 1990) and is well known for impressive post-breeding dispersal. Nevertheless, it seems there was a particularly well-developed southward dispersal this year.

11.5 Disposition of Data: All data, in both raw hardcopy format and in an Excel spreadsheet, is held by Michael Force, c/o Dr. Roger Hewitt, Antarctic Ecosystem Research Division, Southwest Fisheries Science Centre, La Jolla, CA. Roger.Hewitt@noaa.gov or mpforce@mac.com.

11.6 Problems and Suggestions: Coverage could be improved immensely if there were two or more observers. The marine mammal data is ancillary to the bird strip transect data because one observer cannot adequately survey for both simultaneously. Moreover, additional observers would allow a watch rotation thereby minimizing fatigue. More importantly, a second or third observer would allow data to be collected in such a way as to minimize flying bird bias.

11.7 Acknowledgments: I want to thank Mark Prowse, Derek Needham, and Michael Soule for making available to me the underway-environmental data obtained from the Scientific Computer System and for assistance with the spreadsheet. The use of a portable GPS receiver provided by Adam Jenkins is also gratefully acknowledged. A special thanks goes to Dr. Roger Hewitt for his support and assistance with some crucial aspects of the data analysis. Thanks to the bridge officers of the *R/V Yuzhmorgeologiya* for providing welcome hot drinks during some frigid watch periods. Lastly, I want to thank my fellow zooplankton team members for their support during the transits.

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Table 11.1 Effort summary.

	Stratum 1 Tierra del Fuego	Stratum 2 Northern Drake Passage	Stratum 3 Southern Drake Passage
# of transects (total=137)	34	40	63
minutes of effort (total=3935)	975	1162	1798
km of trackline surveyed (total=1467)	340.9	506.7	619.4
total birds	2603	706	637
area surveyed (km^2)	102.3	152.0	185.8
density (birds/km^2)*	25.4	4.6	3.4
mean SST (°C)	8.6	6.6	3.3
mean surface salinity (ppt)	33.15	34.02	33.81
mean seastate (Beaufort)	4	5	6

* includes flying birds

Table 11.2 Frequently observed species (>1% of total observations in at least one stratum)

Species	Tierra del Fuego				Northern Drake Passage				Southern Drake Passage			
	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†
Macaroni Penguin *(Eudyptes chrysolophus)*	3	0.12	0.03	6	12	1.7	0.08	5	n/r	n/r	n/r	n/r
unidentified penguin *(Eudyptes sp.)*	24	0.92	0.23	24	14	1.98	0.09	13	n/r	n/r	n/r	n/r
Wandering Albatross *(Diomedea exulans)*	4	0.15	0.04	9	5	0.71	0.03	8	9	1.41	0.05	11
Royal Albatross *(Diomedea epomophora)*	31	1.19	0.3	47	5	0.71	0.03	10	1	0.16	0.01	2
Black-browed Albatross *(Thalassarche melanophris)*	616	23.67	6.02	97	67	9.49	0.44	65	87	13.66	0.47	56
Gray-headed Albatross *(Thalassarche chrysostoma)*	24	0.92	0.23	29	6	0.85	0.04	13	47	7.38	0.25	43
Antarctic Giant Petrel *(Macronectes giganteus)*	75	2.88	0.73	59	10	1.42	0.07	18	21	3.3	0.11	19
Southern Fulmar *(Fulmarus glacialoides)*	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	157	24.65	0.84	17
Cape Petrel *(Daption capense)*	2	0.08	0.02	6	n/r	n/r	n/r	n/r	86	13.5	0.46	13

Table 11.2 (cont.)

Species	Tierra del Fuego				Northern Drake Passage				Southern Drake Passage			
	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]
Soft-plumaged Petrel *(Pterodroma mollis)*	1	0.04	0.01	3	1	0.14	0.01	3	22	3.45	0.12	16
Blue Petrel *(Halobaena caerulea)*	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	12	1.88	0.06	6
Antarctic Prion *(Pachyptila desolata)*	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	17	2.67	0.09	11
Slender-billed Prion *(Pachyptila belcheri)*	16	0.61	0.16	12	183	25.92	1.2	40	2	0.31	0.01	3
unidentified prion *(Pachyptila sp.)*	11	0.42	0.11	9	359	50.85	2.36	43	34	5.34	0.18	32
White-chinned Petrel *(Procellaria aequinoctialis)*	15	0.58	0.15	29	1	0.14	0.01	3	16	2.51	0.09	11
Sooty Shearwater *(Puffinus griseus)*	1500	57.63	14.66	74	1	0.14	0.01	3	5	0.78	0.03	5
Wilson's Storm-Petrel *(Oceanites oceanicus)*	147	5.65	1.44	41	9	1.27	0.06	18	29	4.55	0.16	27
Black-bellied Storm-Petrel *(Fregatta tropica)*	n/r	n/r	n/r	n/r	9	1.27	0.06	18	68	10.68	0.37	44
unidentified diving-petrel *(Pelecanoides sp.)*	6	0.23	0.06	18	9	1.27	0.06	15	10	1.57	0.05	13

Table 11.2 (cont.)

Species	Tierra del Fuego				Northern Drake Passage				Southern Drake Passage			
	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]
Imperial Shag *(Phalacrocorax atriceps)*	60	2.31	0.59	32	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r

§: number of birds observed expressed as a percentage of the total birds recorded in the stratum
*: includes flying birds
†: number of transects with a detection expressed as a percentage of the total number of transects in the stratum
n/r: not recorded
nomenclature follows Clements (1991)

Table 11.3 Rarely observed species (<1% of total observations in at least one stratum)

Species	Tierra del Fuego				Northern Drake Passage				Southern Drake Passage			
	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†
Rockhopper Penguin *(Eudyptes chrysocome)*	9	0.35	0.09	9	7	0.99	0.05	5	n/r	n/r	n/r	n/r
Magellanic Penguin *(Spheniscus magellanicus)*	1	0.04	0.01	3	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r
Light-mantled Albatross *(Phoebetria palpebrata)*	n/r	n/r	n/r	n/r	1	0.14	0.01	3	1	0.16	0.01	2
unidentified giant petrel *(Macronectes sp.)*	1	0.04	0.01	3	1	0.14	0.01	3	n/r	n/r	n/r	n/r
Kerguelen Petrel *(Lugensa brevirostris)*	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	5	0.78	0.03	8
Stejneger's Petrel *(Pterodroma longirostris)*	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	1	0.16	0.01	2
Westland Petrel *(Procellaria westlandica)*	7	0.27	0.07	15	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r
unidentified *Procellaria* *(Procellaria sp.)*	4	0.15	0.04	9	2	0.28	0.01	5	3	0.47	0.02	5
Greater Shearwater *(Puffinus gravis)*	22	0.85	0.22	21	1	0.14	0.01	3	n/r	n/r	n/r	n/r
Manx Shearwater *(Puffinus puffinus)*	5	0.19	0.05	6	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r

Species	Tierra del Fuego				Northern Drake Passage				Southern Drake Passage			
	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]	# of birds observed	unadjusted species composition (%)[§]	density (birds/km^2)*	frequency of occurrence (%)[†]
Magellanic Diving-Petrel *(Pelecanoides magellani)*	2	0.08	0.02	3	2	0.28	0.01	5	1	0.16	0.01	2
Common Diving-Petrel *(Pelecanoides urinatrix)*	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	1	0.16	0.01	2
Cattle Egret *(Bubulcus ibis)*	1	0.04	0.01	3	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r
Snowy Sheathbill *(Chionis alba)*	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	1	0.16	0.01	2
Dolphin Gull *(Larus scoresbii)*	1	0.04	0.01	3	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r
Kelp Gull *(Larus dominicanus)*	6	0.23	0.06	12	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r
Antarctic Tern *(Sterna vittata)*	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	1	0.16	0.01	2
Southern Skua *(Catharacta antarctica)*	1	0.04	0.01	3	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r
Chilean Skua *(Catharacta chilensis)*	8	0.31	0.08	12	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r
South Polar Skua *(Catharacta maccormicki)*	n/r	n/r	n/r	n/r	1	0.14	0.01	3	n/r	n/r	n/r	n/r

Species	Tierra del Fuego				Northern Drake Passage				Southern Drake Passage			
	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†	# of birds observed	unadjusted species composition (%)§	density (birds/km^2)*	frequency of occurrence (%)†
unidentified skua (Catharacta sp.)	1	0.04	0.01	3	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r

§: number of birds observed expressed as a percentage of the total birds recorded in the stratum
*: includes flying birds
†: number of transects with a detection expressed as a percentage of the total number of transects in the stratum
n/r: not recorded
nomenclature follows Clements (1991)

Table 11.4 Marine mammal sightings (listed chronologically)

Sighting #	Species	Date (d/m/yr)	Seastate (Beaufort)	Latitude (°S)	Longitude (°W)	Estimate			Comments
						best	high	low	
1	unidentified pinniped	12/01/02	4	54°16.9	65°25.9	2	2	2	
2	unidentified large whale	12/01/02	6	55°04.9	64°56.2	1	1	1	blow only, possible Humpback
3	Southern Bottlenose Whale *(Hyperoodon planifrons)*	12/01/02	2	56°10.1	64°09.6	1	1	1	adult male
4	Hourglass Dolphin *(Lagenorhynchus cruciger)*	12/01/02	2	56°13.5	54°07.2	3	3	3	
5	Hourglass Dolphin	12/01/02	2	56°17.9	64°04.4	2	2	2	
6	Hourglass Dolphin	12/01/02	2	56°56.0	63°36.2	15	20	12	
7	Hourglass Dolphin	12/01/02	2	56°59.7	63°33.6	3	3	3	
8	South American Sea Lion *(Otaria byronia)*	15/02/02	4	54°37.7	64°58.7	1	1	1	
9	unidentified dolphin *(Lagenorhynchus sp.)*	15/02/02	4	54°59.7	64°57.0	4	6	4	
10	Humpback Whale *(Megaptera novaeangliae)*	13/03/02	4	61°50.4	56°07.8	3	3	3	
11	Minke Whale *(Balaenoptera acutorostrata)*	13/03/02	4	61°50.4	56°07.8	1	1	1	
12	Fin Whale *(Balaenoptera physalus)*	13/03/02	4	61°46.0	56°15.5	2	2	2	probable cow/calf pair
13	Fin Whale	13/03/02	4	61°46.0	56°15.5	4	4	4	
14	Fin Whale	13/03/02	4	61°46.0	56°15.5	7	8	6	tight cluster, actively feeding

Sighting #	Species	Date (d/m/yr)	Seastate (Beaufort)	Latitude (°S)	Longitude (°W)	Estimate			Comments
						best	high	low	
15	Humpback Whale	13/03/02	4	61°46.0	56°15.5	1	1	1	
16	Fin Whale	13/03/02	2	61°41.3	56.23.1	2	2	1	
17	Fin Whale	13/03/02	2	61°41.3	56.23.1	1	1	1	
18	Humpback Whale	13/03/02	2	61°41.3	56.23.1	2	2	2	
19	Fin Whale	13/03/02	2	61°36.9	56.29.2	4	5	4	
20	Fin Whale	13/03/02	3	61°32.1	56°35.7	1	2	1	
21	Fin Whale	13/03/02	5	61°07.0	57°11.5	2	3	2	
22	unidentified large whale	13/03/02	6	60°43.2	57°44.2	1	1	1	blow only, possible Humpback
23	Fin Whale	13/03/02	6	60°35.5	57°55.1	1	1	1	
24	Southern Bottlenose Whale	14/03/02	6	57°52.7	61°28.8	1	1	1	adult male
25	Killer Whale *(Orcinus orca)*	15/03/02	3	54°51.5	64°54.0	6	8	5	
26	unidentified pinniped	15/03/02	4	54°47.1	64°53.5	4	4	4	possible South American Sea Lion
27	unidentified pinniped	15/03/02	2	54°41.6	64°52.7	1	1	1	
28	Minke Whale	15/03/02	3	54°40.4	64°52.5	1	1	1	
29	unidentified large whale	15/03/02	4	54°35.0	64°52.3	1	1	1	possible Fin Whale
30	Peale's Dolphin *(Lagenorhynchus australis)*	15/03/02	4	54°25.5	65°08.0	15	18	15	bow riding for almost 30 minutes
31	Peale's Dolphin	15/03/02	6	53°57.4	65°56.9	5	8	4	

12. Operations and logistics at Cape Shirreff, Livingston Island; and Copacabana, King George Island, Antarctica, 2001/02; submitted by Jessica D. Lipsky and Rennie S. Holt.

12.1 Objectives and Accomplishments: During the 2001/02 field season, the AMLR Program occupied a field camp at Cape Shirreff, Livingston Island, Antarctica (62° 28'07"S, 60° 46'10"W) to support land-based research on seabirds and pinnipeds. The camp was occupied continuously from 14 November 2001 through 13 March 2001. The AMLR Program provided logistical support to the Copacabana field camp on King George Island (62° 10'S, 58° 30'W), which is the site of seabird research funded by the National Science Foundation.

Four personnel (S. Trivelpiece, C. Thiessen, R. Hollingshead and M. Romano) and provisions were deployed from the R/V *Lawrence M. Gould* to the Copacabana field camp at Admiralty Bay, King George Island on 12 October 2001.

A four-person field team (M. Goebel, I. Saxer, D Scheffler and J. Lyons), along with provisions, equipment and supplies, arrived at Cape Shirreff, Livingston Island aboard the R/V *Nathaniel B. Palmer* on 14 November 2001. Scientific activities were quickly initiated. Maintenance of the campsite and bird blind observation also began.

One person (L. Shill) and field supplies were deployed to the Copacabana field camp on 17 November 2001 from the R/V *Nathaniel B. Palmer.*

Two additional personnel (Steve Emslie and Mike Polito) and supplies arrived at the Copacabana field camp from the R/V *Yuzhmorgeologiya* on 14 January 2002.

One person (W. Trivelpiece) and supplies arrived at the Copacabana field camp on 17 January 2002 from the R/V *Calstar.*

Three additional personnel (R. Holt, B. Parker and V. Vallejos) and supplies arrived at the Cape Shirreff campsite from the R/V *Yuzhmorgeologiya* on 16 January 2002.

One person (W. Trivelpiece) and supplies were deployed at Cape Shirreff from the R/V *Yuzhmorgeologiya* on 5 February 2001.

One person (S. Trivelpiece) departed Copacabana on 18 November 2001 aboard the R/V *Explorer.*

One person (L. Shill) departed the Copacabana camp on 17 January 2002 aboard the R/V *Calstar.*

One person (M. Goebel) was retrieved from the Cape Shirreff field camp on 8 February 2002 aboard the R/V *Yuzhmorgeologiya.*

One person (R. Hollingshead) was retrieved from the Copacabana field camp on 5 February 2002 about the R/V *Yuzhmorgeologiya.*

On 13 March 2002, a six-person team closed the Cape Shirreff field camp for the season. All personnel (R. Holt, W. Trivelpiece, B. Parker, I. Saxer, J. Lyons and D. Scheffler), along with garbage and equipment requiring maintenance for protection from the winter weather, were removed and loaded aboard the R/V *Yuzhmorgeologiya* for return to the United States.

On 1 March 2002, a two-person team (C. Thiessen, M. Romano) closed and departed for the season the Copacabana campsite by the R/V *Yuzhmorgeologiya,* along with trash and retrograded equipment.

Daily radio communications were maintained by Cape Shirreff with the R/V *Yuzhmorgeologiya* and Copacabana field camp by SSB radio.

12.3 Recommendations: Support provided by the R/V *Yuzhmorgeologiya* and the AMLR scientific complement made a significant contribution to the success of the field camp at Cape Shirreff. Use of the Chilean ATV and trailer were vital for transporting materials and supplies from the boat landing to the Cape Shirreff campsite. Thanks to the R/V *Nathaniel B. Palmer* crew and scientific parties during the season's opening at Cape Shirreff and to the R/V *Lawrence M. Gould* during the season's opening at the Copacabana field camp.